TIME STUDY

AND

JOB ANALYSIS

AS APPLIED TO STANDARDIZATION OF METHODS AND OPERATIONS

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PREFACE

The aim of this book is to explain the practical application of Time Study and Job Analysis in simple, non-technical terms. Experience has shown that job standardization when properly tied in with planning and control affords the most effective preventive yet developed for industrial ills. While the technique of the subject is here given in full detail, special emphasis is placed upon the relation of standardization work to problems of management.

The increasing attention being given to industrial management by progressive executives is to be attributed only slightly to the ordinary processes of salesmanship and advertising. The responsible executive, absorbed with the concrete difficulties of the business which he has seen grow up, is naturally skeptical of the assistance to be rendered from any outside source. The industrial engineer, whether employed as consultant or as resident, has won his way because he has been able to sit down with the individual executive and demonstrate plainly and in detail just what could be done for the particular business in question. It has been the logic of actual performance which has demonstrated in plant after plant that:

1. Through the methods of time study and job analysis reliable assistance can be obtained.
2. These methods constitute in no wise a magical formula, but are susceptible of cool and deliberate examination.
3. The work can be done by agencies which the executive can command.

The purpose of the author has been to present in written form just such a plain and coherent explanation of the subject as might be given in a series of conferences with an executive charged with the responsibility of decision.

Job standardization cannot be adopted as something separate and distinct. It is a part of a well-balanced development which must be carried throughout the entire organization. Education of the members of the organization is, therefore, one of the first things undertaken by the analyst or engineer who makes the time study and job analysis and it must continue to receive attention throughout the duration of his services.

Another matter which the engineer must consider, is the relation of job standardization to planning of the work from the inception of the order to the delivery of the finished product. Sometimes the improvement in planning precedes, sometimes it follows the work of standardization; but in any case the success of standardization is closely bound up with the methods by which the product is routed in the factory from process to process. Furthermore, inasmuch as pay and conditions of work—the two great factors in the labor situation—are materially improved by time study and job analysis, the work of standardization has proved of great importance in connection with labor relations. Finally, even sales policies are affected by job standardization. All the factors of the business, in short, are the concern of the engineer who undertakes job standardization.

The book therefore deals with these various related subjects as follows:

In Chapters I to IV, a general review is given of the principles of job standardization and their application to the methods of time study and job analysis.

In Chapters V to VII, the organization of a staff to carry out the work—not merely the temporary force required for

the period of installation but a permanent staff within the plant organization—is discussed in detail from the point of view of the executive responsible for the introduction of job standardization.

In Chapters VIII to XX a detailed description of the technique is given. This portion of the book may be used as a textbook and guide in an actual development of time study and job analysis in a particular case. In this part also emphasis is placed upon applications of the technique described to the permanent needs of the plant.

In Chapters XXI to XXIII job standardization is considered in its relation to industrial problems. The material here given will be found useful in connection with sales activity and with practical adjustment of labor relations.

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William O. Lichtner.

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CHAPTER I

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Development of Industry

Modern industry has developed from the small shop. The small shop was usually begun and built up by one man, who was a workman possessing special skill and some qualities of leadership. With the growth of the business more men, more materials, more machinery, and more space became necessary, and these in turn necessitated more supervision and control than could be exercised by the individual owner. As long as the owner himself did the work with the aid of an apprentice or two whom he had taught, the problem of comparing methods did not exist, because there was only one method for each piece of work—the method employed and approved by the craftsman-owner. Each piece of work was begun and completed by one man.

Comparison of Methods under Small-Scale Production

As soon, however, as there came into the shop more men, who had perhaps learned the trade elsewhere and whose work the owner could not continuously oversee, it became evident that there should be some way of comparing the various methods so as to avoid mistakes and get the most satisfactory results. The greater the number of men employed, the more necessary it became to look about for the best methods of operation. While the business was still comparatively small, the owner could make comparisons by talking over the results with his workmen and by carrying on his study of methods informally; such a procedure was economical and was all that was

necessary. In a large and growing business, however, this sort of management meant waste of time, materials, and capital.

Disappearance of Centralized Knowledge

The growth of his business soon obliged the craftsman-owner to withdraw from intimate contact with the shop into the increasing confinement of the office, while the transfer of the business to the second generation or to a wholly new set of owners, often absentees, completed the separation of the managers from the details of production. At this point the supervisory duties of the owner were broken up and delegated to superintendents and foremen, who were usually of less ability than the owner and in addition were not spurred on by the fact of personal ownership. Thus, even though the company was committed to large-scale operations, the original small-scale manufacturing methods of the founder remained practically unchanged, with the added disadvantage that they were invariably carried out by less able and less interested men.

Requirements of Large-Scale Production

The first requirement of large-scale production is a scientific investigation of needs and methods calculated to restore the centralization of knowledge which disappeared along with the disappearance of the omniscient craftsman-owner. Through organized knowledge the management is enabled to set standards suited to the needs of equipment, materials, methods, and quality and quantity of production. The setting up of such standards, with special rewards for their attainment by employees and with the proper planning of work by a new and specially trained section of the management provides the second requirement for large-scale production, viz., co-ordination of the efforts of all members of an organization, in the same way as the personal supervision of the craftsman-owner

served to co-ordinate the efforts of the few men who worked immediately under his eyes.

Scientific Management

Carried to its most effective limit, standardization of work and planning thereof in accordance with the information obtained and the standards set, involve what has been termed scientific management. This term is appropriate, for it expresses briefly the idea of applying science to management. While it is true that management can be but relatively "scientific"—for that matter applied chemistry itself is no longer the pure science practiced exclusively in the laboratory—nevertheless the following definition shows that the adjective is not wholly misapplied.

The name scientific management is used to characterize that form of organization or procedure which is based on principles and laws established by a thorough investigation of manual and machine processes, materials, tools, equipment, and physical and psychological operating conditions; which standardizes operations and provides for instruction in new methods of execution; and which develops and maintains precise and automatic control, including the organization of the personnel, the processes, the materials, and the equipment in such functional co-operative relations as will utilize the highest technical skill available and capable of development in planning, supervising, and executing.

The Human Element

The most significant fact about scientific management is that it involves the human as well as the mechanical element in an enterprise. Scientific management affects the organization from the chief executive down to the lowest-paid workman or clerk, and may be itself affected by the action of any member of the organization. This is the case because in analyzing

facts the first step will always show some weaknesses in the system in use, and in order to cure these a change will be necessary which, large or small, will alter the routine of some employees. The natural impulse of almost every man is to resent change; and unless all the employees are given to understand the nature of the change to be made, they will not fall in readily with the new routine. On the other hand, once their co-operation is secured they become a part of the plan. Such a relationship makes it possible to take the second step, and then the third step, and so to continue the development until more and more people become parties to the new arrangement.

Co-ordination of Functions

The development brought about by scientific management is in the direction of the co-ordination of functions. Every business may be likened to the human body. As in the case of the body a business may function to all outward appearances very well and seem to be in perfect health; and yet ever so often and at unexpected times troubles will arise, although few suspect that the cause is a weak or improperly functioning member. The aim should be, therefore, to perfect each function independently according to its needs, yet co-ordinated properly with every other function. To achieve this aim is the purpose of scientific management.

Perhaps the easiest way to illustrate the problem of coordinating functions is by means of a sample organization chart, as shown in Figure I. This chart represents a combination of the best practices of many lines of business operating on scientific management principles. At the head of an organization the board of directors, executive committee, and general manager direct the affairs of the company through three groups of activities, each one functioning through the one above. The activities of the first group may be designated as divisions, the second as departments, and the third as sections.

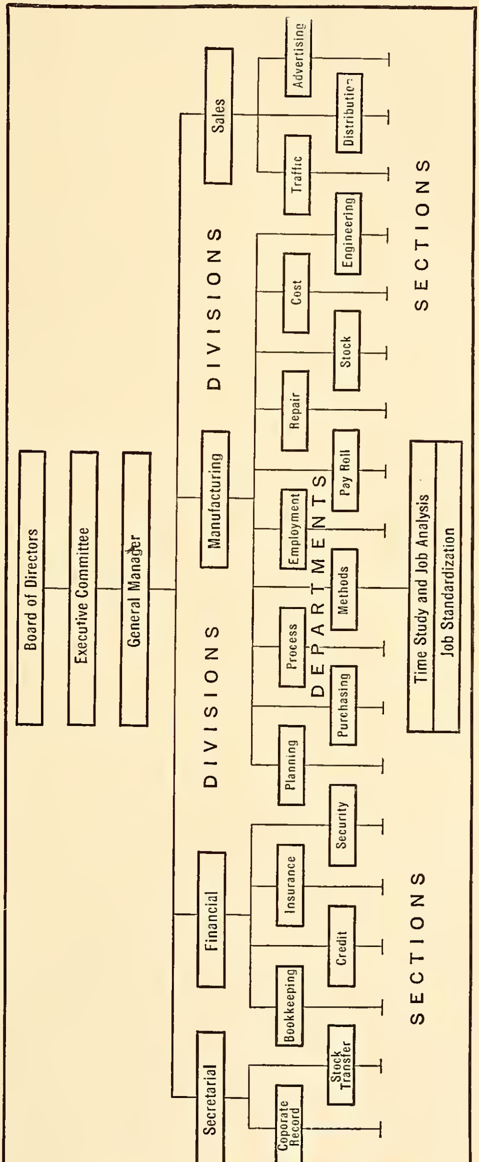


Figure 1. Industrial Organization Chart.

The time study and job analysis function is here given as a section of the Methods Department, of which it is the core, as the entire analysis of conditions and determination of standards is handled by means of time study and job analysis under the one man, viz., the analyst who is head of the Methods Department.

The importance of definite functions has been underestimated in small-scale methods of large-scale production. While many of the functions shown on the chart can in a small establishment be combined under the direction of one man, the chief functions are essential to the conduct of any manufacturing concern. Scientific management solves the problem of their correlation and execution. To this end it demands that responsibility be assumed by those in authority, to whom responsibility belongs, and by them delegated down through proper channels, and thus the process is in the nature of an education and a development. This can only be accomplished by educating and developing the entire organization.

Specialization in Industry

The education and development of an organization requires men who have specialized in the application of science to industry. Already large-scale production has familiarized business with the principles of specialization.

Centuries ago, for example, when clothing was first made, the maker used to grow his own wool, prepare it for weaving, and then make the garments. Today we find the clothing manufacturer purchasing all the materials which go into the finished garment. He does not concern himself with the detailed manufacture of wool, lining, canvas, thread, buttons, and so on, but the manufacture of each of these items represents a large industry in itself. Each of these latter industries depends to a large degree on the clothing industry for its existence.

As the industries specialize in this way, so the workmen in each industry specialize. Again to use the clothing industry as an example, it was not long ago that a clothing worker made almost a complete garment from start to finish. Today practically no industry is conducted in this way. One garment represents today the combined efforts of some hundred different people, each contributing his own special share to the manufacture of the complete article. Something of the kind is found in every industry, whether steel, clothing, wood-working, camera, automobile, button, or candy-making. From every point of view we have grown into an age of specialization.

The Industrial Engineer

In industry the major field for the specialist, the field of management, belongs to the industrial engineer. The industrial engineer interests himself in doing for complex modern business what the craftsman-owner used to do in a smaller but adequate way for his shop. He becomes intimately acquainted with the details of operations, methods, machines, materials, and equipment, and determines standards for each. These standards are developed by combining the technique of the actual process known to the management with the technique of management in possession of the engineer.

Too often the function of an industrial engineer is conceived to be similar to that of, say, an illuminating engineer engaged to solve some definite problem of lighting. According to this view the work of the industrial engineer consists merely in getting the facts of the situation and drawing conclusions in the form of specifically limited plans which the executive may accept, revise, or reject to suit his ideas. While this plan of procedure is applicable to certain types of engineering problems, it is impracticable in accomplishing that development of the organization which is fundamental to scientific management.

Development of Industrial Engineering

The history of the industrial engineer is brief. This branch of engineering was inaugurated by Frederick W. Taylor, not more than twenty-five years ago, at the Midvale Steel Company of Philadelphia. His work proceeded chiefly along two lines: first, the development of tools specialized both as to design and material, and second, the development of standards of production. The results of the experiments on the cutting of tools revolutionized the machine and steel industries, and gave to all industry the present high-speed cutting tools. The result of the second series of experiments was the development of rules and principles of which the effect was yet more revolutionary. When tested, these principles were found to apply to industry of every sort, not only to factory and machine shop but to construction and office work as well. Their application was given the name of scientific management.

Job Standardization

The same method was used in all Dr. Taylor's researches—the analysis of the job through the study of time. In the development of tools, specialized as to design and material, the object is—though the fact may not at first be apparent—to attain better quality in a shorter time. This is no less true in the development of rules and principles. A study of time is required in order to analyze the job properly.

A little thought will make clear to anyone that in considering any job he always "senses" that one method of doing it takes longer than another, although later he may completely forget the time element which he actually used.

A number of concerns today are employing many of the principles of job standardization without realizing that they are doing anything technical and without giving these principles a formal and specific name. One of the drawbacks to such unconscious use of the principles of job standardization

is that the work is not consistently carried through and that the data and standards are not correlated to further the development of the business as a whole. Nevertheless changes are being wrought even by such casual and partial application of the principles of job standardization.

Saving of Material

In a certain factory not long ago an analyst came across an operation on which any workman who stopped to think could not help being conscious of waste resulting from the operating method in use. The operation in question consisted of cutting large rolls of gummed paper into single sheets. The paper was used for labels on bottles and had to be cut into large flat sheets 50 inches long by 40 inches wide. This cutting was done by winding the paper on a drum 50¾ inches in circumference, until 80 layers of paper had been wound. The 80 layers of paper when sawed through at one point produced 80 single sheets. In laying these 80 sheets out flat on the table it could be seen that the sheet first wrapped on the drum was 50¾ inches while the eightieth or top sheet on the drum was 52¼ inches. This meant a waste of paper on every sheet from nothing up to 1½ inches or an average of ¾ of an inch to each sheet of paper 50¾ inches in length by 40 inches in width. By changing the method of cutting the paper into individual sheets on what is called a rotary cutter or sheeter it was found that besides saving this ¾ inch, an additional ¼ inch could be saved on every sheet. Under the old method an extra allowance of ¼ inch in the length of each sheet had to be made to allow for the saw's tearing the cut edge; under the new method this allowance was not needed. The difference between the amount of paper wasted before standardization and that wasted after standardization, as shown in Figure 2, meant a saving to the company of some $20,000.00 a year.

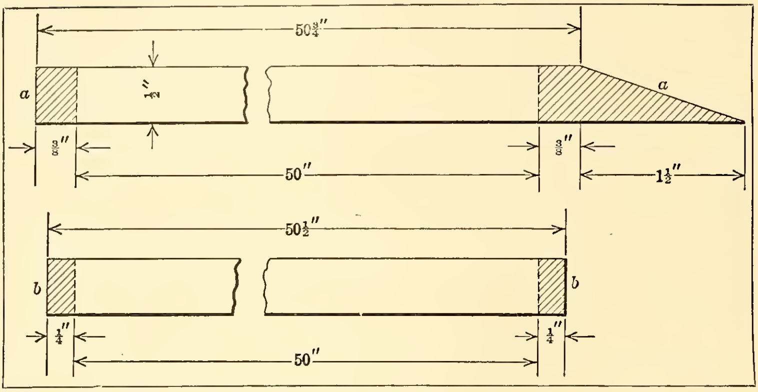


Figure 2. Diagram Showing Reduction of Paper Waste by Job Standardization:
(a) Amount of paper wasted before standardization
(b) Amount of paper wasted after standardization

Saving of Time

Many instances of criminal waste of time occur in offices, banks, and the like, but it is a waste which is usually accepted as unavoidable. Job standardization, though originally started in the factory, is equally usable in the office. It is no less important in the office than in the factory to know whether it is cheaper to do work by hand or by machine. For instance, the making out of time tickets, manufacturing orders, and similar forms takes considerable time and can be reduced as much to a routine as any factory job. This operation was studied in one office, where time tickets were being written by hand. Analysis, as indicated in Figure 3, showed that it took less time to make out from one to twenty tickets by hand than by mechanical means, but that for a larger number of tickets the multigraph was speedier and more economical. While the figures and conclusions vary with the amount of information to be filled in on the particular form, such analysis is one that could be made with advantage in a number of offices.

Reduction of Overhead

In any factory using machinery it is economical to keep the machines running as nearly as possible 100 per cent of the time, and so to reduce the overhead. Take, for example, the operation of sawing lumber into definite lengths for making packing boxes. Certain kinds of goods require a box two feet long, others two feet and nine inches, others four feet, and so on. The customer may require five hundred two-foot boxes and one hundred three-foot boxes. At the Pioneer Box factory manufacturing so-called "wire bound" boxes, the boxes are made of thin veneer lumber, attached to thin wood cleats by means of stapling the wires on to them. Sheets of veneer come in long lengths which are cut by means of an automatic cut-off saw into the lengths required for the particular boxes for which they are to be used. In some cases several

MAKING OUT TIME TICKETS

By multigraph	By rubber stamp	By hand	No. of tickets
10.62	9.14	5.3	10
11.32	10.64	10.6	20
11.67	11.41	13.25	25
12.02	12.22	15.9	30
12.72	13.76	21.2	40
13.42	15.30	26.5	50
14.12	16.84	31.8	60

Figure 3. Time Ticket Analysis

lengths can be cut out of one piece of veneer, so that the machine is rigged up with three or four saws on the arbor in order at one cutting to square off the two ends and cut the sheet into two or three pieces. The thickness of the veneer varies in accordance with the use to which the boxes are to be put. The machine can therefore cut a number of sheets of veneer at one time. Thus a standard was set for veneer ⅛",

¼″ and ⅜″ thick. The final result of the studies was to eliminate using one of the two saws which had been previously used the major part of the time. This not only afforded more floor space in the factory for other purposes of manufacturing, but released one of the saws for use in another plant which the company was erecting. The operation of sawing is shown in Figure 4.

Job Standardization in Industry

If job standardization is recognized as a fundamental business policy it does much more than save a few hundreds of dollars here and a few thousands of dollars there—it brings about a decrease in cost throughout the entire business. Although this is by no means the whole benefit effected by scientific management, it is that part by which the most substantial gains are produced both for capital and labor. Without it an organization can have only crude and inadequate standards. Job standardization develops these crude standards in such a way that production is increased per machine, and in consequence individual and unit costs are reduced. On this account job standardization is sometimes called the cornerstone of scientific management.

When a concern decides to take up job standardization it means that men are going into the factory to make a detailed study of each operation in co-operation with the present staff of superintendent, foremen, and workmen in order to develop the knowledge of processes possessed by this staff and then to put this knowledge into concrete, usable form. This may seem to many, especially on first thought to the workman, a transfer of power and control from employees to owners, and is likely therefore to arouse the workman's opposition. As both sides, however, gain a fuller understanding of the problem of the management, this feeling changes from resentment to one of enlightenment and co-operation. It must be borne in mind,

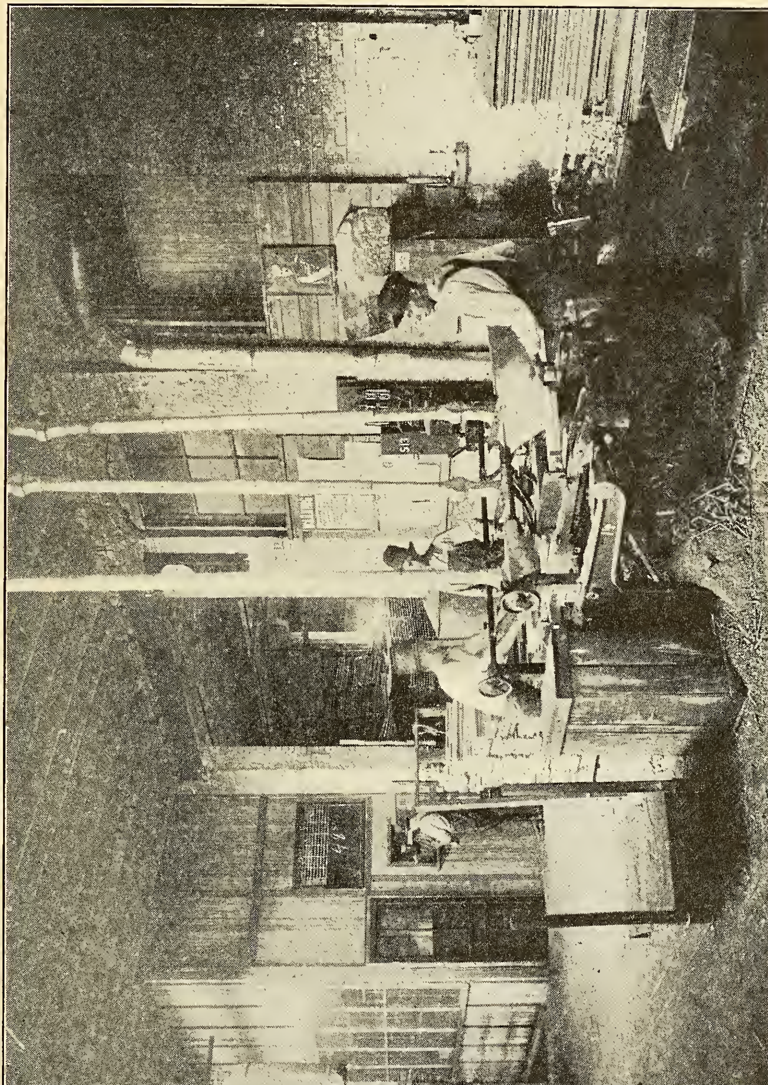


Figure 4. Automatic Cut-Off Machine in Use after Standardization

however, that changes are always hard to make, and the hardest are those which extend over a long period of time, so that the effort has to be made again and again. The management adopting job standardization as a business policy will find it a hard policy to live up to. It must be prepared not only to educate and re-educate its employees, but itself to adopt an attitude of willingness to learn.

Results of Job Standardization

The results of job standardization, however, far more than repay any effort involved. They are twofold:

1. Increased production per machine or individual, of better quality at a lower cost.
2. Establishment of better labor relations.

Both these results are due to the same cause: that facts in the hands of the management as well as in the hands of the employees have replaced half-knowledge and rule of thumb formerly followed by the employees only. Neither result, moreover, can be attained unless job standardization is undertaken as part of scientific management. Under the new system the "labor question" becomes less acute, because one of the aspects of that problem, the amount of work the employee should perform, is accurately ascertained by time study and job analysis in determining standards of production, and so the atmosphere is cleared for a discussion of the second aspect, the amount of wages which the employee should receive for his work. There is hope for agreement when discussion proceeds on a basis of facts. Moreover, wages can be larger without loss to the employer when the production is increased through better methods and through individualized instruction and assistance to the employee, who is no longer hampered by defective machinery, tools, supplies, and materials, changes in orders after the work is in the machine, and innumerable

other delays common to unplanned production. Idle time is reduced, work and equipment are ready when wanted, mistakes made are fewer, and when made the responsibility can be definitely fixed. This last is an especially important point, because under unscientific methods the blame was always distributed and no one person in particular was really responsible.

CHAPTER II

JOB STANDARDIZATION DEFINED

Purpose of Job Standardization

Job standardization may be defined as the method of determining and applying standards of operating in productive and distributive enterprises for the purpose of increasing production and lowering costs. In considering this definition it is particularly important to consider the objects in view, namely increase of production and reduction of costs.

Production and Costs

Increase of production is a phrase which conveys but a vague idea to many persons. The two ways to increase production are, first, to increase the number of working hours, and, secondly, to decrease the time taken to perform a certain operation. The first method—increasing the number of working hours—involves too drastic a change to be other than temporary even were it advisable. The second method, however—decreasing the time taken to perform the operation—is practical, sane and just.

In some cases job standardization is looked upon as a mere speeding-up device, which decreases the time by driving the employee. This is sometimes true when the work of standardization is done by a novice, but not when it is handled by an experienced analyst. The analyst is interested only in results that are permanent; the aim of his work is to set standards which will not, as a rule, call for much greater exertion on the part of the employee. Often job standardization makes possible the substitution of mechanical devices for sheer brute

strength, of easier ways of doing some part of the work through instruction, or of proper tools properly sharpened for the poor ones taken care of by the workman himself. For example, analysis of free-hand sawing of ivory nuts from which buttons used on clothing are made resulted in developing a mechanical device which gripped the nut while it was being sawed after it had been properly placed by hand, and thus relieved employees from the tension of constantly watching to protect their fingers from the saw.

Where the work is increased after analysis, the experienced analyst makes a careful study of the fatigue factor so as not to require undue exertion from the employee.

Increase in production, moreover, is possible with a reduction of costs. For this reason specific mention of costs is made in the definition of job standardization. All the factors of production—material, equipment, workmen, and degree of quality to be attained, as well as time—are involved in the effort to lower costs. It is because of the failure on the part of many to appreciate the importance of this one fact when the subject of increased production is raised that the principles of job standardization have too often been misunderstood and misapplied. The notion that it is only necessary to "call down on the carpet" the superintendent, when costs go up, or the other notion that, when production goes down, every job of every sort should immediately be put on a piecework basis, must be abandoned for a more far-sighted policy, which includes the determination and application of standards of operation.

Time, the Unit of Measurement

The determination and application of standards imply the necessity of some common unit of measurement. Obviously the unit must be one of the factors of production. With different industries, however, in different localities and under

different conditions, all the factors of production, except time, show a difference in character. Time is the only factor of production applicable to all conditions. Time, therefore, is used as the most convenient measure of production. It is the universal yardstick. Accordingly, the chief tool of job analysis is a time device—the stop-watch. The analyst studies the time taken to perform even the smallest part of each method of operating. He talks in terms of time. His conclusions are formulated in terms of time.

Other Factors Affecting Production and Costs

The choice of the factor of time as the common unit of measurement probably accounts for the mistaken notion that job standardization includes nothing more than the timing of work. It should always be kept in mind, therefore, that except to correlate all the factors of production, time may not be so important as emphasis would make it appear. Other factors affecting production and costs and, therefore, the method of determining and applying standards are as follows:

1. The *material* from which the product is made.
2. The *equipment* by which the product is made, whether elaborate, semi-automatic machinery, or simple hand-worked tools.
3. The *workmen,* who are the agents of production. This factor, which is the most important, is the one most commonly neglected.
4. The *quality* of the product. Even in the lowest grade of goods, there is a certain standard, whether it is clearly defined or not, below which everything is classed as "seconds."

An experienced man can see almost from the start along what lines the greatest increase can be made at the least cost. All the factors of production he keeps in mind, and their par-

ticular manifestations serve to modify his procedure. The standards he sets are not standards of time alone, but *standards of method* which affect all these factors.

Material

Economy in the amount of material used is most important. It can generally be brought about by a little more care or a little more planning on the part of the workman. Waste of material is of course much harder to measure than the direct waste of money, as for example the money handled by a bank. A dollar bill has a definite value, it does not change in form, and must be accounted for to the last penny. If a bank cashier were as careless in handling dollar bills as the ordinary workman in handling materials the cashier would not long hold his job. A workman, however, may hold down a job for many years and annually throw away thousands of dollars —and yet be considered efficient.

Workmen in shops daily handle such a large volume of material that they become careless and waste great amounts of it. For instance, in a wire mill great quantities of wire are wasted in preparing and weaving it. In construction work carpenters waste large quantities of lumber by carelessly picking up any piece that is longer than they require. This means a great many short ends which are practically wasted. Examples of this kind occur day in and day out because the workmen do not realize the vast amount of money lost. It is astounding to the engineer, in going from plant to plant, to find this identical factor of ruthless waste appearing in varying degrees everywhere. Great savings are possible and with no expense at all simply by seeing to it that the workmen exercise a little care.

In some shoe factories this problem of saving material has been studied, and a plan has been devised whereby the pay of a cutter is based, not on the speed with which he cuts, but on the amount of leather he saves. Such an arrangement can

be made because the cost of a shoe is influenced more by the price of leather than by the price of labor. Similarly in making leather garments, the cutters could do from 20 per cent to 25 per cent more work if they did not have to conserve material, but since the cost of labor on cutting leather garments—such as a leather overcoat—is only 10 per cent of the cost of the material, it means a minimum cost of production for them to work slowly enough to use the minimum of material. The expense of the material and its proportion to the total cost are matters for careful consideration. In some cases special investigation is required to determine exact standards for the amount of material to be used for each order.

Equipment

Improvement in equipment brings large returns, which generally require little or no extra effort on the part of the employee. Usually, however, they do involve an expenditure of money on the part of the management, and great care should be exercised in making recommendations for the purchase of new equipment. Too often very simple changes in machinery cost considerable money. Since changes which at first look small sometimes necessitate a good deal of experimenting, it is better, as a general rule, to put the present equipment into first-class order and utilize it for daily manufacturing purposes while some one machine is being experimented upon and fully developed. The answer to the question as to whether a change in machinery pays is necessarily phrased in terms of *time saved*. Nevertheless, the quality factor cannot be overlooked in giving the answer, since the machine is sometimes less able to adapt itself to individual variations than is the hand controlled by the brain of the craftsman. The human element, too, enters into the answer.

There is a popular saying that "necessity is the mother of invention." In manufacturing, inventions have often re-

sulted from the pressure of competition. But the necessity which has done the most to bring about the invention of machinery has been the high price of what used to be called "cheap labor." The writer recalls an instance in which a workman found that he had an exceptional abhorrence of monotonous, physical work. This workman, therefore, devised an attachment which automatically stopped the machine when anything went wrong or rang a bell when the finishing point was reached. This bell he wired out to the engine room where, as the work was progressing, he sat and peacefully smoked his pipe. After he had made a number of inventions, the company discovered that whenever he was placed on work which was particularly difficult or monotonous, he would work out some means of overcoming the monotony so that he could rest and smoke. They, accordingly, placed him on jobs where improvements in the machinery were desired. Thus his ingenuity was directed to their mutual benefit.

The Workman

The workman is a factor of which much has been lately written. There is a great deal of talk about the psychology of the workman, as if there were some special brand of psychology which applied to a human being who was in overalls, and did not apply to a human being who worked where he could have clean hands and a white collar and act as an office attaché or executive. It is well to keep in mind the fact that each human being sees the advantages he wants or needs from points of view that depend upon whether he is an executive, a full-fledged artisan, or an unskilled workman. It is no more of a mistake for the analyst to approach an executive from the standpoint of an illiterate workman than it is to talk financing and management to this same illiterate workman.

In planning the campaign, in talking to the men, in laying down methods for them to follow, in giving them incentives

to practice the methods introduced, the man carrying on job standardization should always appreciate the limitations—and, even more, the possibilities—of the human material.

The class of men performing the operation—whether they are American or foreign-speaking, whether they are quick to grasp a point or slow of wit, whether they feel kindly or the reverse toward the management—all these things have an effect on the methods followed. Neither the physical nor the mental demands should be made too great under new standards.

The question of physical demands is a matter of fatigue study. The factor of fatigue naturally enters to a greater or less extent into all work, in fact, into everything we do. The method of job standardization includes the transfer to other jobs of employees not fitted to the work they are doing, on the basis that each operation imposes distinct physical and mental demands and that it is no more right for the clerk to strain himself physically trying to do the blacksmith's job than it is for the blacksmith to undergo the mental strain of the clerk. Proper and reasonable standards are set for each class of work, which will make it possible for a workman to keep at his work year in and year out without any danger of prematurely shortening his life. Although there are certain types of work which are very heavy or require very close application, on the majority of shop operations the machine does the major part of the work. With operations of this type the question of fatigue is not of so much moment as when purely manual or mental effort is involved. The allowance for fatigue can be determined from time studies upon which the standards have been based. With heavy work or machine work requiring great activity, special fatigue studies are essential.[1]

The nature of the incentive to do the work in a standard time varies with the mental make-up of the men. It should

[1] For a discussion of fatigue see Chapter XIV.

not lead them to overdo, a tendency which can be further prevented by supervising their work. Piece rates, premium plans and so on are often makeshifts, as anyone who has had anything to do with them realizes. When not adapted to the situation they are sometimes even the cause of labor troubles. The only similarity which exists between any of these methods and job standardization is the desire to measure the output and to make the pay commensurate with its quality and quantity.

Quality

In the majority of operations the quality factor is one of the most important, for every product must have some quality standards. Practically without exception no company has any absolute standards for quality, but the standards vary more or less with the whims of the customer, the salesmen, and often the executives. Accordingly the first result of job standardization is to determine a definite standard of quality.

When job standardization is started there is always a movement on the company's part to stress the quality factor, using it as an excuse for low production. Nevertheless it can be stated as a general fact that the quality is better after job standardization than before, because of the closer attention given by the workman when he is on an accurately calculated incentive basis, and because of closer supervision of the workmen and of the materials.

Broadly speaking, "quality tempers quantity." In other words, as the quality factor becomes greater the quantity becomes less, not in direct proportion but proportionally less in relation to each operation. An exception to this rule was noted on a job in Toronto, Canada, where a sewing operation done by machine was unsatisfactory because the stitches did not hold, although the machines were operating at the speed and tension designated by the machine manufacturers. The com-

pany had about decided to do the work by hand when another clothing manufacturer who happened to visit the plant was told of the trouble. He saw that the machines used a very small drive pulley and stated that at his plant they used one twice as large. A pulley double the size was ordered from the stock room and put on the machine, of course doubling its speed. The workman then tried the machine and to everyone's surprise it turned out a stitch of first-class quality. The speed of the machine caused just the right tension. This is but one case in which greatly improved quality was obtained without decrease in quantity.

Co-ordinating the Factors

The way in which all these factors of production and costs have to be tied together and considered simultaneously with the time factor can best be illustrated by taking a specific example. To find a good example, however, is not easy because the reader should visualize without effort the details connected with it, and he cannot do this if the operation requires technical or special knowledge. Even in giving talks before employees in their own factory the difficulty of choosing a particular operation with which all the employees are familiar is apparent. Since few persons are perfectly familiar with the details of any job but their own, and since, moreover, few have the ability to picture mentally an operation which they have seen but not actually performed, most persons are likely to miss the significant points of an example. Some time ago a certain man, more ingenious than others, hit upon the idea of describing a job which was not inside of the factory or office but one nevertheless with which everyone was familiar—shining shoes in the ordinary shoe-shining parlor. The success of this example was so marked that it has been chosen as the one to illustrate the application of the elements of job standardization. The operation of shining shoes is shown in Figure 5.

Figure 5. One of the Elements in Shining Shoes

The average man's idea of standardizing shoe-shining would be to go into a parlor and with the permission of the "boss" take a great many time studies, such as the detailed study shown in Figure 6, of the amount of time taken by each part of the operation. These amounts could then be compared with a view to finding what seemed a reasonable time for each part, considering *in a general way* the standards expected. If the observer had enough common sense, he would take a few additional studies to make sure that the amounts really were reasonable before he asked the boss to teach the men how to use the methods the best men studied were using and to leave out unnecessary motions. Finally, he would tell the men that if they polished a pair of shoes well in the time set they would be paid more money. Although this method is common, it requires a long time to get results. When obtained, moreover, the results are unsatisfactory because they are not based on clearly defined standards. A general routine of procedure is being followed without clear understanding of the objective or of the relation of the objective to the factors involved in shining shoes.

Production Factors in Shining Shoes

The object in studying shoe-shining is to find the best method of shining each type of shoe—black, tan, calf, kid and so on—so that this method can be made the standard The first general estimate involves the relative importance of the various factors making up the method of operating. An estimate in this case is especially easy because shoe-shining is an isolated operation, without relation to other operations, whereas in an office or a factory the place of the particular operation in the process as a whole effects the plan of action.

In the case of shoe-shining the customers are always in a hurry, and it is greatly to the advantage of the shop to give

Time *8:00* to *8:44*

No. Study *1*
Observer *C. Dieter*

File
Date *4/20/21*

Operation *Shining Shoes*

Department *Shoe Shining*

Location *3rd Chair*
Employee *H. Blank* Rate *30¢ hr.*

Implements *Cleaning Cloth, drying cloth, 2 brushes and polish cloth*
Materials *Cleaner and Black Polish*

Conditions and Remarks
Poor Light

Employee fast worker

Each reading is for 2 shoes

Elements	a	b	c	d	e	f	g	h	i	j
	0.20	0.50	0.60	0.25	0 92	0.32	1.01	0.76	0.22	0.54
	0.27	0.54	0.59	0 21	0.99	0.35	0.98	0.71	0.23	0 52
	0.22	0.70	0.61	0.26	0.90	0.34	1 02	0.70	0.21	0.30
	1 15	0.50	0.61	0.22	0.97	0.36	0.95	0.72	0.25	0.57
	0.21	0.49	0.60	0.22	0 97	0.33	0.96	0.71	0.21	0.40
	0.22	0.50	0 60	0 23	0.93	0 34	0.98	0.73	0.25	0.45
	0.21	0.60	0.65	0.22	0 94	0.31	0 99	0 70	0 23	0.47
	0.27	0.30	0.71	0.29	0.70	0.33	0 60	0.40	0.90	0 48
Av. Time	0.229	0.547	0.620	0.237	0.945	0.335	0.985	0.721	0.228	0.420

D-1 = Look for Polish
D-2 = Chatting with Fellow Worker
D-3 = Look for Brush

Detail Elements
a *Rub of dust*
b *Apply cleaner*
c *Remove cleaner*
d *Apply polish 1st time*
e *Polish with brush*
f *Apply polish 2nd time*
g *Polish with brush*
h *Polish with cloth*
i *Brush clothes*
j *Make change (take money)*
k *Time needed per pr.*
l
m
n
o
p
q
r
s
t
u
v
w
x *Unnecessary Delays*
y *Necessary Delays*

Sy	Read	Ex	Notes	Sy	Read	Ex	Notes
	0.00			j	38.72	0.47	5.32
a	0.20	0.20		a	38.99	0.27	
b	0.70	0.50		b	39.29	0 30	
c	1.30	0.60		c	40.00	0.71	
d	1.55	0.25		d	40.29	0.29	
e	2.47	0.92		e	40 99	0.70	
f	2.79	0 32		f	41.32	0.33	
g	3.80	1.01		g	41.92	0.60	
h	4.56	0.76		h	42.32	0.40	
i	4.78	0.22		i	43.22	0.90	
j	5.32	0 54	5.32	j	43.70	0.48	4.98
a	5.59	0.27					
b	6 13	0 54					
c	6 72	0.59					
d	6 93	0 21					
e	7.92	0 99					
f	8 32	0.40	D-1				
	8 67	0.35					
g	9.65	0 98					
h	10.36	0 71					
i	10.59	0.23					
j	11 11	0.52	5 79				
a	11 33	0 22					
b	12 03	0.70					
c	12 64	0 61					
d	12.90	0.26					
e	13.80	0.90					
f	14.14	0 34					
g	15.16	1.02					
h	15.86	0.70					
i	16.07	0.21					
j	16 37	0.30	5.26				
a	17.52	1.15	D-2				
b	18.02	0.50					
c	18 63	0.61					
d	18 85	0.22					
e	19.82	0.97					
f	20.18	0 36					
g	21.13	0 95					
h	21.85	0 72					
i	22.10	0.25					
j	22.67	0 57	6 30				
a	22.88	0 21					
b	23 37	0 49					
c	23.97	0 60					
d	24 37	0 40	D-3				
	24.59	0.22					
e	25.56	0 97					
f	25.89	0 33					
g	26 85	0.96					
h	27 56	0 71					
i	27.77	0.21					
j	28.17	0.40	5.50				
a	28.39	0.22					
b	28 89	0.50					
c	29.49	0.60					
d	29.72	0.23					
e	30.65	0.93					
f	30.99	0 34					
g	31.97	0.98					
h	32.70	0 73					
i	32.95	0.25					
j	33.40	0.45	5 23				
a	33.61	0.21					
b	34.21	0.60					
c	34.86	0.65					
d	35 08	0 22					
e	36.02	0.94					
f	36.33	0.31					
g	37.32	0.99					
h	38.02	0.70					
i	38.25	0.23					

Sy	Read	Ex	Notes	Sy	Read	Ex	Notes

Av. Time
0.229
0.547
0.620
0.239
0.945
0.335
0.985
0.720
0.222
0 420
5.258

Figure 6. Study Sheet Showing Details of Shoe-Shining Operation

instant and rapid service. In order to set a standard of time required to shine a pair of shoes of a given type—which will serve the purpose of showing how many bootblacks should be on hand and make it unnecessary for a customer to wait even at rush hours, as well as to measure each bootblack's ability—the observer will take time studies of the way in which the best bootblacks do the work. While he is taking the time studies and setting the time standards, he will note the requirements limiting the time taken—the materials, the apparatus, the man himself, and the quality.

The desired shine is obtained more by applying "elbow grease" than by applying paste. Some employees apply two or three times as much paste as others, with no better results. By determining the number of applications necessary the waste of both material and time can be reduced to a minimum.

In many shops the shoes are dried by being fanned with a cardboard fan, which takes considerable time. An electric blower shortens the time on this element of the work, reducing the total time for shining shoes correspondingly. If tests show that the time saved by installing a blower would pay for the expense it should be recommended. Otherwise, the shoes should continue to be dried by a cardboard fan and sufficient time allowed for this.

One way of improving both quality and speed without introducing mechanical changes is to cut a two inch strip of cardboard and place this carefully in the top of a shoe so as to protect the customer's hose from becoming soiled when applying the liquid, paste, brushes and cloths.

Shining shoes is not easy work. While dull hours sometimes provide all the rest needed, it is probable that some allowance in setting time standards must be made for fatigue. This will be especially true if the work is done by boys.

The factor most seriously affecting time required is the quality, or the amount of shine desired. No matter how great

the haste of the customer, he is always "fussy." The degree of brilliance desired should be carefully determined and impressed on the bootblacks. In order to eliminate the tendency of the bootblacks to slight the work, the "boss" will be obliged at intervals to check up the work by noting the feet of customers going out.

During the entire analysis the methods adopted, the ways of maintaining quality, the amount of rest and all the factors included in the standards should be adapted to the type of bootblacks employed.

The result of the analysis will be that each pair of shoes will be better polished and with less labor and material, and that more satisfied customers can be accommodated even at rush hours because the shoes are polished in a shorter time.

Wide Applicability of Job Standardization

The details of the way in which job standardization is conducted and standards of operating determined and applied, vary with the complexity of the operation under observation. The shoe-shining illustration is about as simple as could be found. At the other extreme is repair work in a machine shop. Nevertheless, in spite of the wide range in the complexity of the problems, the same factors are involved—material, equipment, workman, quality—and time is always the measure by which standards are determined. For both operations, job standardization is the method to increase unit production and lower unit costs.

CHAPTER III

METHOD OF PROCEDURE

The Four Phases of Analysis

The processes of analysis described in the last chapter are carried through in a more or less definite order, and fall, in a general way, into four divisions. The transition from one phase to another is so gradual, however, that one usually somewhat overlaps the other. Quite often it is necessary to go back from a later phase to an earlier for verification or correction. At the end of the study, for instance, after the standards have been set, the analyst may find it a wise precaution to check his standards by an all-day time study.

The four phases of job standardization are:

1. Preliminary work
2. Taking time studies
3. Analyzing studies and setting standards
4. Applying standards

The first phase, that of "preliminary work," gives the analyst a bird's-eye view of the field he is to enter and the workmen with whom he is to deal. There is some way best adapted to each situation, by which the right kind of start can be made. On the very first operation studied the preliminary work requires considerable time, for it is necessary not only to make a survey of the particular operation which is to be under observation but of all the preceding operations, except of course in the case of the initial operation, and also of some of the subsequent operations. Moreover, before undertaking detail time study, the analyst instructs the members of the organization in its purpose. As the analyst becomes acquainted with the departmental requirements and as the members of the

organization see that the work is as much to their advantage as to that of the company, the preliminary work on each operation takes less time.

The second phase, that of "taking time studies," is one commonly thought of when the subject of job standardization is discussed. The first step in any analysis is to get a record of what is being done. In order that the record may be used for purposes of comparison this means, in industry, that the time element must be recorded, since time is a very important factor in production. To the casual observer "taking the times" seems to be exceedingly simple. It is only necessary, however, for him to try his hand at the seemingly simple task to realize the skill required to take the detailed times of a very simple operation.

The third phase, that of "analyzing the studies and setting the standards," requires experience and special training. Anyone can work up the time values and set a so-called standard, but unless the standard is developed so as to consider the human as well as the mechanical factors in such a way as to allow an employee to perform the work with a minimum of energy and a minimum of material in the minimum time, the standard is not correct and will do more harm than good.

The fourth phase, namely that of "applying the standards," is the one which proves how well the other three phases have been handled. The standards both of method and time must be put into effect in such a way that they are easily assimilated by the organization. It is not until the employees are accomplishing the work according to the standards set that the case is established to everybody's satisfaction. The proof of the pudding is in the eating. When a man gets a taste of something good he wants more and passes the word to all his coworkers so that they also begin to want it. This is the result found in all plants when the work of the analyst has been properly performed.

A comprehensive idea of the field covered by job standardization can be given by outlining the method of procedure to be followed in each phase.

Preliminary Work

In adopting any new policy the human reaction to it should be taken into account; otherwise the policy will be a dead thing, merely a matter of forms and routine. This result would be especially unfortunate in job standardization, because the members of the organization where the studies are to be made are the people who not only can and must assist in its introduction, but who also must be relied upon to maintain it.

The analyst working in the factory is necessarily concerned with the speeds of the machines, the equipment, and the materials used, in order that he may be able to determine the effect of each. He should get from the superintendent the authority to have the foreman see that conditions are changed in accordance with the tests laid out by the analyst. The superintendent should see that the foreman fully understands his authority to co-operate with the analyst. It is important that the support of the foreman be gained, and to this end the analyst should explain to him the method of job standardization and what it will accomplish. The analyst should convince the foreman that he will be kept constantly informed of what is being done so that he can continue to direct his organization intelligently and obtain its full co-operation.

General Survey of Field

The other part of the preliminary work concerns the problems involved in the particular operation. The man who is introducing the work must gather together all available data on the subject in order to have a general knowledge of the situation as it is then and there and its possible future improvement. A general survey is made of the department to

learn: present methods, stock of materials and their condition, number and types of machines and, in addition, cost records on the operation, including records of production, rates of wages, and number of employees. All this information is essential for the purpose of comparing present with final production and costs.

All the operations in the room are related to each other in some way and no single one can be considered independently of the others. The consideration of the situation as a whole and of the general features of the operation takes a varying length of time. If the department is large and there are a great many operations, or if the work is laid out so poorly that large changes are necessary, the survey will take a long time. In other cases it may be possible to do all this work mentally without making any records.

The preliminary survey may suggest changes in the machines, their locations, mechanical parts, or speeds; the advisability of preparing more carefully the materials, or of packing and delivering them so that they can be handled easily; or changes in the method itself. Much careful study should be given the possible changes, backed up, when necessary, by tests. The changes, however, should not be made until after the detailed studies to be made later have proved their efficiency. The analysis should be worked out to a point where the outlines of the final result are clear before any suggested changes are recommended for final adoption.

Taking Time Studies

Having made the preliminary survey the analyst is now ready to enter upon the second phase, taking the time studies. The preliminary survey has made it possible to lay out a program which will accomplish the work in the shortest time and will secure a responsive attitude on the part of the working force.

Equipment needed in making time studies consists of a decimal stop-watch with a large hand to indicate the fractions of minutes—preferably by hundredths—and a small hand to indicate the minutes; a standard form of time-study sheet; a clip board for holding time-study sheets and watch; a hand tally; and a speed indicator.

In order to learn the elements, several studies should be made. Delays in the various operations, such as "waiting for material," "waiting for tools" and "machine broken down," occur over and over again without any steps being taken to correct them. It is these short, constantly recurring delays, ordinarily unobserved, that are the most common causes of low production. Time studies definitely point these out, and steps should be taken immediately to eliminate them.

In considering which employees should be studied, the foreman should be consulted. It is best during the first observation of the employees and their qualifications as quality or quantity producers, to note what standards of quality have been maintained. The quality standards must be definitely set and used as the basis for all further development.

Detail studies of an operation are made for the purpose of determining the best method of operating. Each operation breaks up naturally into a number of distinct divisions and subdivisions, corresponding in a general way to the individual motions and having definite points of starting and stopping. These divisions are called "elements." The elements, for instance, of the operation of shoe-shining, which has been used as an illustration, are:

(a) Rub off dust.
(b) Apply cleaner.
(c) Remove cleaner.
(d) Apply polish first time.
(e) Polish with brush.
(f) Apply polish second time.

(g) Polish with brush.
(h) Polish with cloth.
(i) Brush clothes.
(j) Make change (take money)

In making the time study the analyst watches the operation performed, noting on his sheet each element and reading the time of his watch at the moment the element is completed. Later in the office he is able to find the time actually taken by each element.

In order to facilitate the recording of the watch readings in making "detail studies" each element should be given a letter or symbol by which it can be identified. The letter "c," for instance, can be jotted down in a second instead of the sentence "remove cleaner" each time the shoe shiner performs this element in his shoe-shining operation, and similarly "h" could be used to symbolize "polish with cloth," "i" for "brush customer's clothes," etc. In the illustration the elements were given a symbol in alphabetical order as they were performed. Another method commonly used for symbolizing elements is to make the symbol mnemonic. With this method the symbol "r" would stand for "rub off dust," "ac" for "apply cleaner," etc. This latter method has been found to be more flexible than using the letters of the alphabet in sequence, because no matter in what sequence the workman may do his work, the analyst will be able instantly and without exertion to follow the work element by element and record all information in the time-study sheet which may be needed later in working up the standard times.

Analyzing Studies

Preliminary work and taking the studies in the factory prepare the ground and furnish the material with which to build. The next step is to construct something tangible out of what up to this point has been a conglomerate mass. Here

the work falls into three divisions: determining the standards, codifying them, and incorporating them into instructions.

In determining the standards the studies which have been taken must be worked up into such a shape that the time of similar elements can be compared, tabulated and averaged. There will also be a record of unnecessary delays and some necessary delays which occurred during the operation. By means of the notes recorded opposite the delays and the frequency with which they occur it is possible to determine what unnecessary delays, such as loafing, should be eliminated, and to allow for necessary delays, such as "tightening the tension on a sewing machine," because delays of this sort will occur so long as human beings are required to do the work.

Formulating Standards

The standards are formulated in terms of time, because, as stated before, time is the yardstick by which to measure the effectuality of each element and operation. The standard time is that time which the employee can fulfil day in and day out without injury to health of mind or body, and therefore the analyst who sets this time should have well-balanced judgment, good technical understanding, and a knowledge of the effect of fatigue upon performance.

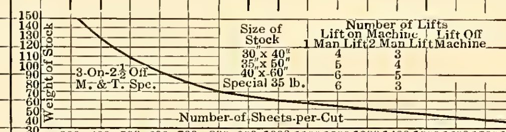
The standard time should first be found separately for each element. Some engineers use a set method of determining the standard time; but the standard time should not necessarily be an average, nor the unit times recurring oftenest in the better performances, nor an average of means after elimination of the high and low extremes; rather it should be a combination of these, governed by conditions. To the sum of the standard times for each element are added the proper allowances as determined for necessary delays, rest, and fatigue. The total constitutes the standard time of an operation. Figure 7 gives a chart of standard times for trimming paper stock.

	Place Stock on Machine per Lift: * 1 Man Lift po	2 Man Lift pt	Special 35 lb. ps	Trim Stock 2 Sides and 1 End per 3 Trims: If 1 Man Lift add this item ao†	30"x 40" tnt	35"x 50" tmt	40"x 60" twt	If stock is un-even add this item aut	Trim Stock 1 Side and 1 End per 2 Trims: Special 35 lb. tso	If 1 Man Lift add this item ao†	30"x 40" tno	35"x 50" tmo	40"x 60" two	If stock is un-even add this item auo	Remove Stock from Machine per Lift: 2 Man Lift r	Special 35 lb. rs	Miscellaneous per Truck Load: Stock Flat m	Stock Uneven mu	Change Jobs per Job: c
Standard Time	0.23	0.40	0.82	0.11	2.52	2.89	3.28	0.13	1.87	0.11	1.81	2.01	2.22	0.13	0.50	0.81	3.48	4.50	4.91
Net Time	0.17	0.30	0.61	0.08	1.87	2.14	2.43	0.10	1.39	0.08	1.34	1.49	1.65	0.10	0.37	0.60	2.53	3.34	3.64
Walk from Machine to Truck Get Stock in Hand	0.03 0.10	0.03 0.09	0.03 0.14																
Carry Stock to Machine	0.04	0.04	0.04																
Jog Stock to Gage Hit Sides & Front with Stick		0.06 0.08	0.23 0.17	0.03 0.05						0.03 0.05									
Run Gage Back for 1st Trim " " " " 2nd "					0.16 0.10	0.16 0.12	0.16 0.13		0.16 0.05		0.16 0.06	0.16 0.06	0.16 0.05						
" " " " 3rd " Push Stock to Gage					0.06 0.07	0.06 0.10	0.05 0.12		0.10		0.07	0.10	0.12						
Set Gage by Hand {2 Times, 3 Times}					** 0.12	** 0.12	** 0.12		0.12§		0.12§	0.12§	0.12§						
Place Pad Under Edge Trim Stock-1st Time					 0.08	 0.08	 0.08	0.10	 0.08		 0.08	 0.08	 0.08	0.10					
" " 2nd " " " 3rd "					0.08 0.08	0.08 0.08	0.08 0.08		0.08		0.08	0.08	0.08						
Throw Waste in Box †† Turn Stock for Next Trim					0.01 0.17§	0.01 0.27§	0.02 0.40§		0.02 0.26		0.01 0.17	0.01 0.27	0.02 0.40						
Run Up Gage for 2nd Trim " " " " 3rd "					0.06 0.10	0.06 0.12	0.05 0.13		0.19		0.10	0.12	0.13						
Run Up Gage for Removing Stock					0.16	0.16	0.16		0.16		0.16	0.16	0.16						
Get Stock in Hand Carry Stock to Truck															0.14 0.04	0.24 0.04			
Even Stock on Truck															0.13	0.26			
Walk from Truck to Machine Hit Sides & Ends of Stock															0.03 0.03	0.03 0.03			
Set Machine for Next Lot					0.21	0.21	0.21		0.21		0.21	0.21	0.21						
Remove Cover Boards (4 per Truck) §§ Place " " (4 " ")																	0.00 0.31	0.00 0.50	
Mark Trimmed Stock Change Truck Card																	0.68 0.66	0.68 0.66	
Change Instruction Card																			3.64

1st Letter
p = Place Stock on Machine
t = Trim "
r = Remove Stock from Machine
m = Miscellaneous Items
c = Change Jobs
a = Add This Item

2nd Letter
o = One Man Lift
t = Two " "
s = Special Case
n = Narrow Stock
m = Medium Width Stock
w = Wide Stock
u = Uneven Stock

3rd Letter
t = Two Sides Trimmed
o = One Side Trimmed



Size of Stock	Number of Lifts: Lift on Machine 1 Man Lift	2 Man Lift	Lift Off Machine
30" x 40"	4	3	
35" x 50"	5	4	
40" x 60"	6	5	
Special 35 lb.	6	3	

* 60 Pound Stock or Under When Trimmed for Litho Printing is a 1 Man Lift Except When Trimmed 2 Sides and 1 End, Then it is a 2 Man Lift.
† This is Due to Last Lift
§ Multiply by 2
** Multiply by 3
†† This Operation Takes Place While Gage is Running Back
§§ Helper Removes Board While Machine is Being Set

Figure 7. Time Study Sheet Showing Standard Times for Trimming Paper Stock

In some cases the standard time may be shorter than that within which the work was previously performed by any one workman, because of the fact that one employee is faster on one element of an operation while on another element a second employee, by the use of slightly different methods, is faster, and these two times have been combined in the standard time. For instance, job standardization on the operation of sewing buttons on men's garments showed that a couple of workmen who were turning out about the same number of garments of the same quality were using different methods. Workman A was found to be very fast in all the elements excepting the actual sewing on of the buttons, while workman B was found to be very fast on the sewing and slow in the other elements. The analyst showed further that workman A used a double thread and made more than double the number of stitches that workman B made and at a slower rate per stitch. Workman B, on the other hand, used a quadruple thread, made less than half the stitches of workman A and took each stitch faster than workman A. The standard, therefore, was set by using workman A's element for all but the sewing, and workman B's element for sewing. By getting B to teach A the use of a quadruple thread and A to teach B how to do the other elements in a better way it was possible for both A and B to increase their production without any greater effort.

Use of Equations

The standards which are developed for an equation should be worked up into as simple a form as possible, so as to require the minimum of work to determine the time of the operation for any particular condition, quantity or specification. Sometimes this codification of standards requires considerable study.

In a few rare cases it has been found that at first it took almost as long to figure the time allowed for a given order

as actually to do the work. In the operation of "blocking cloth," for example, a formula was developed which filled the requirements. This formula appeared complicated to those not familiar with the particular line of work under consideration, but aside from the time taken to use the formula in figuring the job it was in reality quite simple. The formula was later reduced to the form given in Figure 8. The figuring

Explanation of Symbols

c — constants per section. For lays on the fold $c = 0$
$c_{2}1$ — constants per cut per piece
c_3 — constants per cut per part
c_4 — constants per cut for dividing and blocking exact
c_5 — pin facing constants
g — number of garments
L — number of layers
n — total parts in any piece
p — number of pieces
s — time for style value for each part
T — total time
u — pin facing time per layer
v — time required to obtain (shake) and even each layer of each piece
w — variables per cut, per part. For parts marked 1 cut, $w = 0$
y — number of sections. For Blocking on the Open, $y = 2$; except for F to O pcs. when $y = 1$

Determination of L

4 size lays on the open, $L = \frac{g}{2}$	2 size lays on the fold, $L = \frac{g}{2}$
2 " " " " " $L = g$	1 " " " " " $L = g$
1 " " " " " $L = g$	

Determination of Height of Section for Pieces Blocked on Fold

1. Lays of 2 or more sizes on open. Height of sec. $= \frac{L}{y}$, when y is an even number.
2. One size lays on open. Height of section $= \frac{L}{y}$, for any value of y.
3. Lays on fold—pieces laid on fold. Height of sec. $= \frac{L}{y}$, for any value of y.
4. Lays on fold—pieces laid on open. Height of sec. $= \frac{2L}{y}$, when y is an even number.

Formula I—Blocking Pieces Not Cut Exact

$$T = p\left[y\left\{c_1 + \frac{n(s_1 + \ldots + sp)}{p}\right\} + L\,\frac{(v_1 + \ldots + vp)}{p} + c_2 + n(c_3 + wL)\right]$$

$$= p\left[y\left\{0.001 + \frac{n(s_1 + \ldots + sp)}{p}\right\} + L\,\frac{(v_1 + \ldots + vp)}{p} + 0.022 + n(0.009 + 0.0006L)\right]$$

Figure 8. Formulas for Figuring Standard Times for Blocking Cloth

of the jobs was further simplified by drawing a curve, as given in Figure 9, for each style of garment that was to be

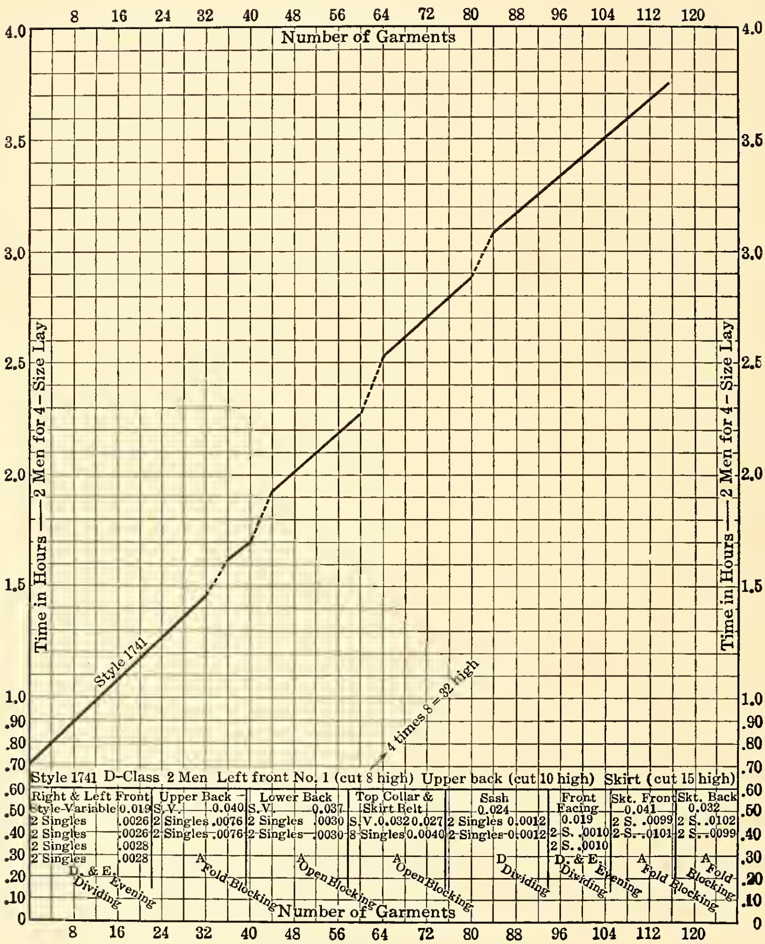


Figure 9. Graphic Curve Showing Time Needed to Block a Given Number of Garments of a Given Style

manufactured in quantity. The time required to establish a curve is considerable, but once made it is good for an entire season. During the past season about 75 per cent of the jobs to be figured were taken from the curve; the remaining 25 per cent were special jobs requiring the use of the formulas.

In general, it is better to put the final standards into tabular form rather than curves. On operations having a large number of variables, however, it is found to be good practice to use curves.

Written Instructions

Standards will not remain standard very long unless written instructions are drawn up covering every factor in detail. There are two reasons for putting instructions in writing: the first is that while two people with different conceptions may believe that they are absolutely in accord so long as they are talking together, they will see at once their points of difference if one of them puts his conception into writing; the second reason is that ideas change unconsciously, and without written instructions the original idea may be lost and the standard relaxed.

The written instructions should be of two sorts, general and detailed.

General instructions should include such points as the capabilities of the machine, speeds at which the machine is to be run under each varying condition, equipment necessary, relation of the work of a particular employee to that of some other employee or move-man, placing the equipment in a convenient place, or the storing of machine parts in proper racks.

Detailed instructions should cover the exact method of operation. It is evident that when a definite, carefully planned method has been worked out on which the standard times are based, the employee should use this method. Skilled workmen, however, frequently vary in the manner of doing certain

elements of an operation, and if they can accomplish the task within the standard time, without using up unnecessary energy, little is to be gained by insisting on their following exactly the standard practice. Moreover, should the workmen fail to perform the operation within the standard time, they should be instructed in the standard method, and thereafter be required always to follow it. These instructions are also of value to the management since they describe the method in use when the standard times are set.

Application of Standards

The work of job standardization cannot be considered complete until the standards are actually put into effect. This is one phase which is not taken into account by many workers on job standardization, who are apt to consider their work finished when they have established the standards. This neglect is chiefly due to the fact that they are accustomed to having piecework rates based on average conditions set by superintendents and foremen, and to having adjustments made up or down, depending on whether the employees strike because the rates are too stiff or whether they earn more money than they were expected to earn. Standards established through job standardization are exact, and are accompanied by a guarantee that they will not be changed unless there is a definite change in equipment or method.

The standard which has been determined as correct is often different from the one by which the employees have been doing the work. In these cases it is easy to see why it is necessary to have an instructor demonstrate to them the best way. In operations where no big change has been made the necessity of having someone on hand when an employee starts working on the new rates is not so evident. Years of experience, however, have shown that such a precaution is desirable. Ordinarily even on piecework the amount done by the various em-

ployees varies enormously, due to the use of different methods, uneven supply of work or of materials, loafing, lack of ability, or lack of interest and belief in the management's good faith. Job standardization can reduce the irregularities in production by attacking the causes and by starting the standards properly. Planning work ahead provides a comparatively uniform flow of work. The other causes are more psychological in nature and resolve themselves into individual manifestations. It is, therefore, better to work with the employees as individuals, starting them one by one, instructing them in standard methods, and convincing them that the standards are just.

Motion pictures may be of great service in applying standards. The advantages of motion pictures showing the performance of an operation that conforms to the standards are threefold. They can be used in instructing new employees in the detail execution of their job. At the most difficult points the picture can be slowed down and all of the employees shown the exact motions performed at these places, at a speed less than would be possible in any actual performance. Finally, the picture puts on record the standards which have been set, and if at any time these are altered or modified the change will be evident, whereas under ordinary conditions the change is apt to escape notice. In this way a new standard may be made or rejected after a test proves its worth.

After the employees on the operation are all working under the new standards the analyst should provide a routine which will act automatically to prevent the reappearance of conditions limiting production. This may be done by having a graphic record kept of the daily earnings as taken from the pay-roll. Figure 10 shows a chart kept in one factory of the employees' earnings, giving the weekly earnings of each employee separately and showing the elements making up the total. The employees in this factory were paid on piecework, plus a bonus if they made the standard on piecework earnings.

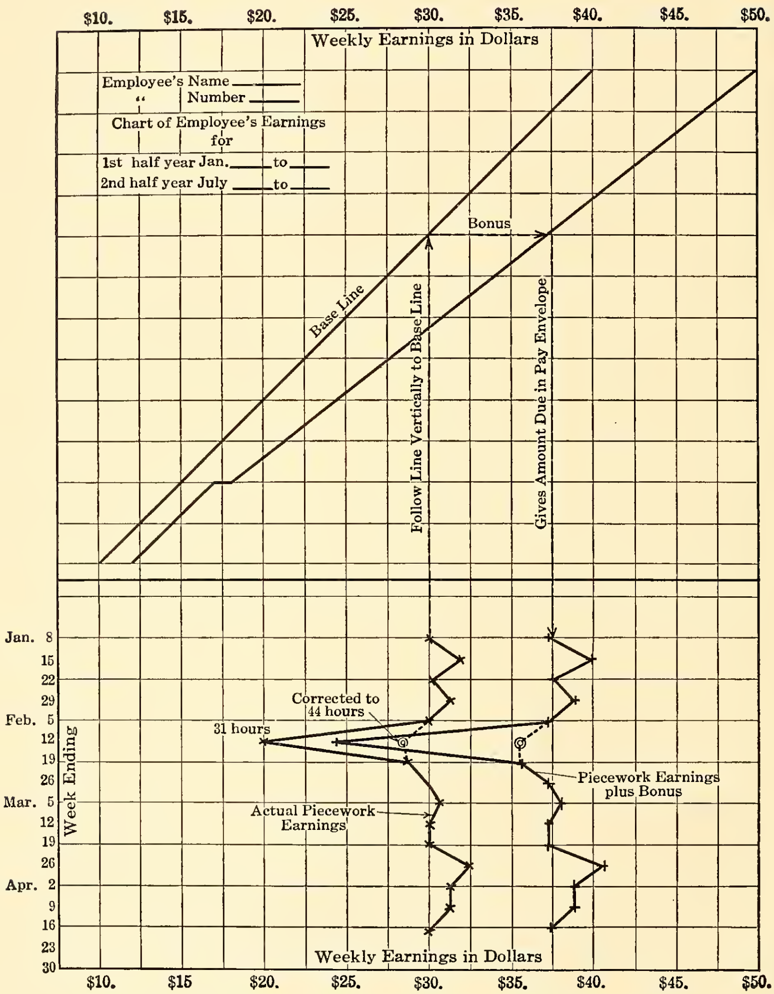


Figure 10. Graphic Chart of Employees Piecework Earnings

The curves at the top show the proportion of the piecework to the bonus earnings, the distance between the lines represents the amount of bonus, and the corresponding point on the bonus-line the total earnings. Thus, if an employee earned $30 on piecework, he would earn $7.50 additional bonus, making a total of $37.50 as shown by the dotted lines. The lower part of the chart shows the actual piecework earnings for each week in one line. The earnings on the chart are figured on a 44-hour basis so that where an employee worked only 31 hours, as during the second week of February, the earnings for 31 hours were increased by 44/31 to correct the chart to the standard number of working hours. The employee is paid, of course, only for what he earns in the actual time worked, but in order to compare the amount of production for the time actually worked it is necessary to refigure it on the common basis of a 44-hour week.

The methods department looks over the record every week, investigating any prolonged or frequent failure to approximate the maximum pay and correcting the cause of the failure. Further departmental records in graphical form showing actual production compared with the maximum, analysis of machine time and employees' earnings, amounts of delayed time, departmental proficiency, and a weekly analysis of total department time, give the management a constant check on the way in which the work is being done. The checks complete the work of applying the standards because they provide for their perpetuation.

CHAPTER IV

RESULTS OF JOB STANDARDIZATION

The Executive's Point of Interest

The method of procedure taken up in the last chapter is applicable to every plant, in spite of the common opinion that "every plant is different." This being true, any instances of results, even though taken from particular industries and operations each one of which is "different," are of general interest. In this chapter, therefore, a few illustrations are given of results in individual cases, three of which involve considerations vital to any industry: the elimination of useless operations; the saving of materials through standardization; the establishment of a rational bonus system.

The executive is interested in results as they affect the whole plant rather than as they affect particular operations. For his benefit, therefore, before giving illustrations of the three points just cited, we transcribe a statement[1] by the Eastern Manufacturing Company, of the general results obtained through scientific management:

> (a) An increase in wages has resulted from the installation of this system of task and bonus and the workers appear more happy and satisfied with their work owing to the fact that they are making more money and turning out a good day's work.
>
> (b) Since the introduction of scientific management, this Company has organized a service department whose principal function is to look after all matters pertaining to the health, comfort, and contentment of all employees. This

[1] Made to the Congressional Labor Committee (1916) in connection with stop-watch legislature.

department employs all new help and makes as careful a selection as is possible, endeavoring to secure for each position those who are physically and mentally suited to the work. Where the health of the worker is not good an effort is made to assign him work where there will be as little as possible physical strain. There have been no ill effects on the health of any of the operators employed on task and bonus as there is no undue strain placed upon them while working under these conditions.

(c) The nature of the work done in this mill is such that accidents are not liable to happen. No reports of accidents to workers on task and bonus have been made since the introduction of this system.

(d) Weekly earnings of employees who have been placed on task and bonus have increased from 20 to 50 per cent.

(e) Since the first of January, 1916, this Company has been able to reduce its hours of labor from ten to nine without increasing the cost of production.

(f) The increase in output since task and bonus have been established varies in different departments from 20 to 75 per cent.

(g) The cost of product as effected by the work on which task and bonus system is applied has decreased on various operations in amounts ranging from 10 to 25 per cent. This decrease in cost takes cognizance of the fact that the overhead or indirect expenses are increased under the system of scientific management over what they were under the old type of management, but this increase of indirect labor is figured in the cost of production which shows a reduction in spite of this additional cost factor.

(h) There has been a marked improvement in the quality of the product due to the rigid inspection which has been made on all work done under task and bonus. This is evident by a decrease in the criticisms which have been made on our product by our customers.

Eliminating Useless Operations

The operation of "opening and laying out" cloth in a bleachery preparatory to bleaching is a good example of the

unstandardized conditions found in many plants. A study of the particular plant from which the following illustration is taken revealed the fact that it required nine independent operations to get the cloth out of the bale and on to the truck so that it could be made ready for singeing and bleaching. It took a crew of seven men to handle the goods under these conditions, and since they were busy throughout the day performing first one operation, then another, it was impossible under this routine to eliminate a single man. The foreman in this plant felt that the method in use was better than that in any other mill in the country, and he was a man with many years' experience in a number of different mills. Time study and job analysis, however, soon showed the possibilities of cutting down the number of operations from nine to four, and the number of men from seven to three.

The operations as performed before analysis was made are indicated in Figure 11.

The operations necessary after the analysis had been made are indicated in Figure 12.

Standardizing to Save Materials

The saving which can be effected on any operation may result either from cutting down the amount of time required by a machine or workman, or from cutting down the amount of material used. In operations in which the material cost is the largest percentage of the cost of the operation, an especial attempt should be made to save the material. An illustration of such an attempt comes to mind in the operation of cutting leather hides and furs for use in making overcoats, in which case it became possible to standardize an unstandardized product. The material in this case was 90 per cent of the total labor and material cost. Each pelt was of a different shape and size, each also had imperfections unlike those in any other pelt; consequently those working with this particular product

Cloth was delivered in bales and placed on end at side of room, by store house.

FIRST EMPLOYEE:

1. Bales were trucked to marking tables and stood on their sides.
2. Straps were cut and burlap stripped down.
3. Each piece was lifted to table and arranged with face of cloth one way.
4. Mill yardage penciled on back of each piece was called to clerk.
5. Tar mark or identification mark was stamped on end of each piece by hand.
6. Each piece was carried to wall (20′) and piled on floor.

SECOND EMPLOYEE:

7. Each pile was laid on flat truck.
8. Top and bottom ends of each piece were pulled out.
9. When truck was full ends were thrown over load ready for moving.

Figure 11. Chart Showing Details of "Opening and Laying Out" in Bleachery before Job Standardization

felt that since they had a material which was unstandardized, it was impossible to standardize the amount of leather a workman should use in turning out a definite quantity of coats.

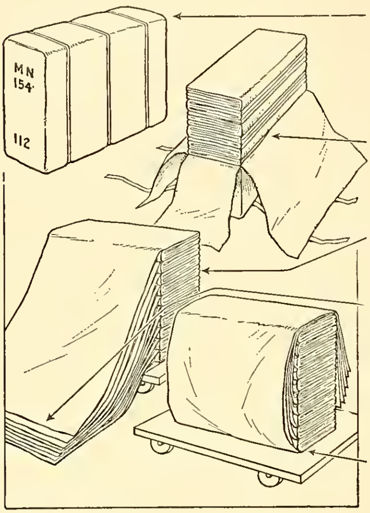


Figure 12. Chart Showing Details of "Opening and Laying Out" after Job Standardization

The detail study showed that even though each skin had its own peculiarities the experienced cutter unconsciously always used the same scheme for getting the greatest quantity of parts out of a given area of skin. This was not realized even by the workmen themselves until their attention was called to it. Standards for varying sizes and quality of the skins were developed through the combined efforts of the skilled cutter and the analyst. Definite instructions based on these standards were furnished to the employees so that they could cut skins to the best advantage. In this industry the workmen have always felt that a number of years was necessary to develop a first-class cutter. The use of standards, however, made the

process of breaking in new men far more simple. The annual saving which resulted from this particular standardization was approximately $16,000.

Rationalizing the Bonus

Many bonus plans were instituted during the war for the purpose of getting maximum production from a plant. Fundamentally, paying a bonus for increased production is good, but without standards many injustices may result. To illustrate: when the employees on an operation have been working with great concentration and producing the maximum quantity, they are unable to produce more no matter how large a reward is offered; whereas when employees on an operation have been loafing, they can increase their production tremendously under the stimulus of a bonus and thereby get a very large return which they do not deserve. For a time bonus systems were very popular, and executives seemed to regard them as a panacea. They soon realized, however, that many of the bonus plans in use were not satisfactory, and would have to be replaced by other and more reliable plans.

One concern, for instance, without having made a thorough analysis of their conditions, hurriedly instituted a bonus system in one department where 150 men were employed, not even taking the time to explain to the employees how the bonus was figured. The workmen, therefore, did not know how much they were expected to do to earn a bonus, but simply found that at the end of a two weeks' period more money appeared in their pay envelopes than heretofore. They very soon realized that the arrangement was baseless and fundamentally wrong, through their checking back and discovering that their pay was not commensurate with their output. The result was that they no longer felt a desire for increased production.

The management also saw that it was necessary to have a thorough analysis made and that a plan based on the analysis

should be worked out in such a way that it could be understood by the employees as well as the management. After three months' careful study the standards were worked up, the entire plan of production was standardized, and the new bonus plan explained to the men so carefully that they understood all of the details. The results were most gratifying. The company record showed that during the first month the bonus plan was in use a saving of more than $4,000 in direct labor was the result. This saving was continued and the men's earnings were increased about 20 per cent more than they had been under the old wage plan, while at the same time the direct labor costs had been reduced more than 25 per cent. The comparative weekly man-hour production for the three groups of men before and after the methods were changed and the new bonus system started is given in Figure 13. It will be noted that at the left of the vertical lines the results of the output before the new bonus plan was put into effect are shown, and to the right of the vertical line the results after introduction of the new bonus plan. The increase in production amounted to about 30 per cent.

Day Work and Defective Economics

The day-work plan of operating is in vogue in many places where it is assumed that the quality factor is so large that it would be unwise to place the work on a measured basis. This mistaken idea, however, is losing ground from year to year, because every situation which has been properly analyzed and developed has proved that the bonus plan is not only practical but also economical and to the interests of the management and the workmen.

In a number of plants the belief obtains that their work is controlled by piece-rate prices, whereas in reality the basis is that of day work because the management guarantees at least the day-work rate to employees on piecework. This

was the case in a certain garment factory. On the operation of pressing the management increased the piece-rate prices several times, but as each increase seemed inadequate, the management finally decided to refrain from any further in-

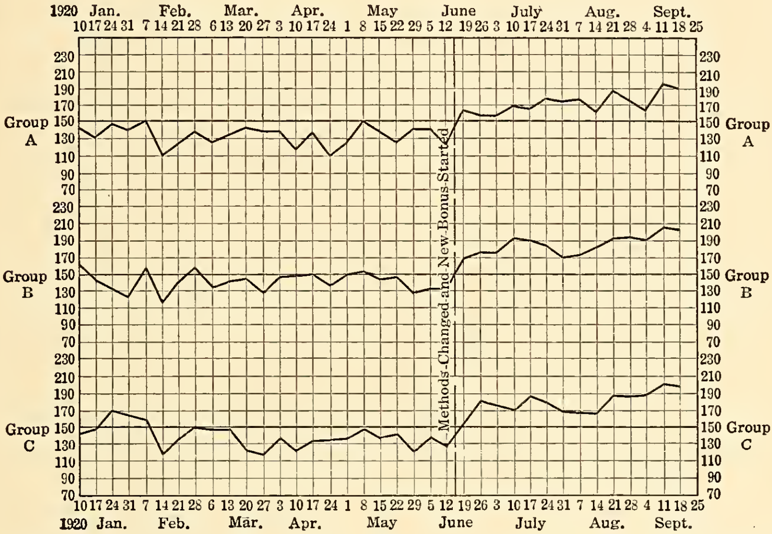


Figure 13. Graphic Chart Showing Comparative Weekly Production for Three Groups of Men before and after Methods Were Changed and New Bonus Started

crease and to pay a guaranteed rate. As a result the pressers earned on an average but two-thirds of their pay, while the other third of their pay represented the amount guaranteed by the company. Analysis of the operation showed that the pressers could without difficulty turn out 25 per cent more production. New rates were set on this basis and the guarantee removed. As a result of the establishment of standards, the pressers were able to earn an additional 20 per cent in wages and correspondingly increased the production.

Emergency Case and Emergency Measure

In most cases the industrial engineer is not called in to undertake a piece of work until the manufacturer has been faced with some problem which requires immediate action. Few of these problems, unfortunately, can be solved quickly enough to meet the immediate need. Occasionally, however, the manufacturer is in a position where such an emergency case can be handled very effectively through emergency measures.

In a certain paper mill in which an industrial engineer had been working for some time a problem came up in the "coating plant" which involved the alternative of closing the plant or of attempting to produce the work more cheaply. The work in question involved a number of operations before the quality of the product could be inspected, which meant that at least a week had to elapse between starting the work and finishing it. The operations involved were mixing the color, coating the paper, finishing it by calendering, and sheeting it so that it could be inspected. Through the continuous watchfulness of the foremen the work seemed to have been done as efficiently as could be expected.

The preliminary survey showed that the operation of mixing the color had been standardized, but in order to standardize the second operation, where the color was applied to the surface of the paper, it would be necessary to determine at different points in the long drying tunnel the proper method of applying heat; the proper quantity of heat to apply; and the relation between heat and humidity. Under the circumstances, elaborate research was out of the question. The work the analyst had done in other departments, which included the keeping of accurate cost records, had resulted in the Cost Department instituting and keeping similar records for the coating department. With these as a basis, he was able to make a study of past performances and draw up the analysis set forth in Figure 14.

Men	Operation	Opportunities for Improvement
1. Mixers	A. Mixing colors	(a) Matching of colors
		(b) Uniformity of colors
2. Coating Crew	A. Tear off wrapper	(a) Reduction in waste, removing wrapper
	B. Coat paper	(b) Uniformity of coating of colors
	C. Dry	(c) Avoiding wrinkles
	D. Wind on rolls	(d) Maintaining proper dryness of paper
3. Calender Men	A. Finishing	(a) Reduction in waste in rethreading stock
		(b) Avoiding wrinkling
		(c) Giving proper finish
4. Cutters	A. Cutting paper to size	(a) Obtaining greatest quantity from a lot
5. Inspectors	A. Quality inspection	

Figure 14. Analysis of Coating Operations in a Paper-Mill

The analyst then took up the question with the foremen and the workmen, showing them the figures of past performances as to quantity of work and as to the amount of waste. He showed them the amount it would be possible to save for each per cent of increase in production and for each per cent saved from wastage. He worked out his statements in dollars and cents, and the men were told that the company would agree to share with them on a half-and-half basis all of the savings which resulted. This meant that every man engaged in the work when all the machines were running would share equally in the bonus.

The management did not think it possible to make very large savings, because the work had always been considered as satisfactorily performed by the entire group. To every-

body's surprise, however, the increase in production for the first year amounted to 21 per cent with a reduction in waste of 20 per cent, which meant a bonus to the men of 26 per cent. This made the average cost about 79 per cent of the costs prior to the time the new system went into effect. After two years the actual money savings as shown by their records, in spite of a 10 per cent shut down, amounted to $43,000 for the year.

CHAPTER V

PERSONNEL REQUIREMENTS

Desirability of Trained Assistance

It is advisable for the company that plans to make use of job standardization to secure, at least, one man from outside the organization who is capable of directing its installation. Although the result of job analysis is greater simplicity and effectiveness of operation, this result cannot be gained without special knowledge of methods.

Any company which attempts the undertaking without the aid of someone possessing the requisite special knowledge, is certain to meet with difficulties and incur uncalled for expenses, and is not unlikely to come to grief in the end over some trivial obstacle. The outside man whose knowledge and ability can help the organization safely across the pitfalls may be a representative of a company of industrial engineers or a graduate of a school in which the subject has been thoroughly taught, who has supplemented his study with practical experience, or even a man whose schooling has been only a wide experience in job standardization. At present, men able to qualify for directing such work are so rare as to be almost unprocurable if some individual concern should desire to retain their exclusive service. As job standardization becomes more general and the training becomes standardized it is to be hoped that the number of competent men will increase.

Eventually the work should be taken over by the company organization. Accordingly, one of the chief duties of the outside man is to train, from among the regular employees, a staff capable of carrying on what he has begun.

Securing the Right Analyst

The size of the job-analysis staff will vary with the size of the plant and the complexity of the industry, but whether it consists of one or two members or of a corps of men, it will be built round the personality of the man directing its work. This man in charge may be called the analyst.

Since the demands made on him will be severe, the analyst must possess exceptional qualifications. Where the ground already has been broken and a basis of co-operation laid, the analyst chosen and trained to succeed the original analyst needs to possess most of these same qualifications.

Combination of Qualities

Because the work is at once inspirational and technical in nature, the ideal analyst needs to possess an unusual combination of qualities. The requirements needed are of two sorts:

1. The ability of the investigator, i.e., the power of collecting and weighing details and of building a constructive program upon these details.

2. The ability of the executive, i.e., the power of directing men and of inspiring confidence and enthusiasm in those with whom he works.

Qualifications for Job Standardization

The analyst is obliged to have the qualities of the investigator in order to direct the detail study, and from the results of such study determine the standards. In this part of the work the qualities he most needs are:

1. *Power* of *analysis.*
2. *Accuracy* in *details.*
3. *Mechanical sense,* if not the training of a practical mechanic.
4. *Ingenuity* in devising improvements.

Since the investigation is not made in a laboratory but among men and women of all sorts and conditions, ability to deal with people is necessary to make the results of the study effective. For this purpose the analyst needs:

1. *Initiative.*
2. *Faith,* in himself and in his work.
3. *Tenacity.*
4. *Health,* with its resulting self-control and steady nerve.
5. *Tact.*

Power of Analysis

The dictionary defines analysis as the separating or unfolding in their order of the elements of a complex body or act. In job analysis it shows itself in the ability to break up a situation, and on a smaller scale that portion of an industrial process known as an operation, into its essentials, not losing sight of the relation of the parts to the whole. Analysis of the data involves sagacious judgments. Its fundamental importance in the work is indicated by the term which has been chosen as the most descriptive of the subject: job standardization.

Accuracy

A slight error in the original calculation may result in serious error when the final standards are reached. Careless work entails costly checking and re-checking. If an inaccuracy is not corrected before the standards are made up, the results are disastrous. Either the standards must be adhered to at the expense of the company or of the employees—and such a course is most unwise, since the defects in these standards will sooner or later be discovered—or they must be altered. All the confidence gained with so much difficulty may thus be lost in an hour. The analyst should not only be exact in his own

work, but quick to detect inaccuracies on the part of those who assist him.

Mechanical Sense

There is comparatively little work in most factories which is done entirely by hand, so that the study of an operation is, to a large extent, a study of machinery, tools, and implements. The analyst should, therefore, be able to recognize the possibilities of mechanical improvements and of labor-saving devices. This does not mean that he must be a full-fledged mechanic, but he should at least be able to give a clear idea of what he wants and should not, as is so often the case with the novice, make recommendations involving large expense and small result. In starting a study of a machine it is good policy to find out the latest improvements which are in the market in order to have the benefit of the best that have been developed; yet at the same time the analyst must guard against being overinfluenced by his enthusiasm or the persuasive talk of a salesman to recommend changing a machine or introducing one of a later type. Small improvements which give large results in proportion to expenditure are very often possible when the situation is handled by an analyst with a well developed mechanical sense.

One simple but useful mechanical device which was worked out by an analyst was a counter used in connection with the work of the girl who inspected sheets of paper in a paper-mill. The operation consisted in taking the sheets from a pile directly in front of her and placing those without soil or blemish on a pile at the right, and the others on a pile at the left. As she placed the sheet on the pile at the right, she naturally moved her right arm and elbow over, so that as the sheet fell upon the pile she lowered her elbow. A counter, such as is used for taking the count on various kinds of machines was attached to the top of the stand at a height even with her elbow

so that, as a sheet was thrown into the pile at the right, her elbow passed over the counter-lever and registered a count. Another counter placed at her left elbow gave a separate count for the paper that fell into the pile at the left. Since the paper after this operation was wrapped and sealed in quantities of five-hundred sheets, a bell was attached to this counter, to ring at the five-hundred mark. When the bell rang the girl put a piece of paper in the pile in such a way as to protrude over the edge. In this manner the operation of subsequently counting the paper was eliminated, which meant not only the saving of time, but also since the quality of some grades of paper is affected each time it is handled, eliminated one occasion for spoilage.

Resourcefulness

It is not enough for the analyst to make an accurate study of methods already in use. He should be able to suggest improvements in the conditions which affect the operation, introduce better methods, eliminate useless motions, and contrive new devices.

The equipment may often be poorly adapted to the uses to which it is put. Benches may be of wrong height or size; sometimes there may not be enough racks and boxes to hold the tools needed. The resourceful analyst who is making a study of the operation will contrive simple improvements to meet these conditions, as, for example, was the case in the operation of die-cut labels in a paper novelty manufacturing company. The labels used on cans, bottles, and packages, with irregular or fancy shapes, are printed on large sheets of paper and are cut out from the sheet with a cutter called a die. A number of these large sheets, fifteen to twenty, are wired or pinned together and the die placed accurately over the label on the top sheet, so that, when hit with a mallet, it will cut accurately the labels on the other sheets in the pile. Figure 15 shows this

method of die-cutting labels by hand. The proper platform to use, the pitch, and the height of the cutting block were carefully determined by experiment, and a slotted spring platform was built two or three inches from the floor, to absorb the

Figure 15. Showing the Standardized Method of Cutting Labels by Hand

greater part of the jar resulting from each stroke of the mallet. The tray in front of the bench shown in the illustration was contrived to hold the dies used to cut the different shaped labels, for one sheet would contain labels of different sizes and shapes, each one, of course, requiring a special die. The rack made possible the placing of the dies in a definite sequence, which eliminated time in looking for a particular die each time a new shape or size was to be cut out of the sheet.

Such adjustments, although simple, demand resourcefulness. Routine studies are too often made by routine men, whereas the competent analyst makes studies which are of constructive value.

Initiative

The newer the work, the more initiative is required. Job standardization is new in every respect, in the individual plant and in industry. There is no well-trodden path for the analyst to follow; he must be able to blaze his own trail.

Faith

Because of the novelty of time study and job analysis it is at first looked upon with hostility, since an innovation is always under suspicion. It is the duty of the analyst to explain away hostility and in its place arouse interest. In order to do this his faith in the work and his own ability to do it must be not only sufficient for himself, but strong enough to communicate itself to those with whom he comes in contact.

Tenacity

The analyst must also have tenacity to carry his plans to a conclusion. It cannot too often be repeated that every change meets with opposition, and that the universal slogan of workmen and executives is "It can't be done." According to Dr. W. R. Lieserson:

> Every human being, no matter how radical he is, is instinctively afraid of change, suspicious of anything that is new. If you are used to eating prunes and oatmeal for breakfast, nobody that comes along with a new idea of breakfast food can get you to change without trouble. He has to spend millions of dollars to prove to you that grape nuts or corn flakes, or what not, has brain food in it; and then not all of you will change.[1]

[1] Bulletin of the Taylor Society, Vol. 5, No. 4, p. 61.

The analyst must first be sure his conclusions are correct, and then be prepared to uphold them in the face of every argument and put through his purpose, thus proving that "can't" is not a word in his dictionary.

Without tenacity, it would have proved impossible for a certain analyst, whose experience the writer calls to mind, to set standards on the beating of pulp for paper. All authorities had agreed, not more than eight or ten years ago, that it was impracticable to determine by any mechanical means when the pulp was sufficiently beaten. They agreed that the only way to tell was by the "feel" of the beater-man, that is, the beater-man would put his hand in the pulp being beaten, and through his sense of feeling be able to determine accurately whether the stock should be left in the beater a longer time. In the face of trade tradition and the best authorities, this analyst successfully persisted in his endeavors to standardize the work and eliminate so variable a factor as the sense of touch of a workman.

Health

One of the chief requisites of an analyst who would be successful is health. He should be a man naturally endowed with a clear, well-balanced mind and a sound body. Any physical defect that is of a serious nature would almost inevitably unfit an aspirant for the work of analyst. He should, furthermore, not be easily affected by the temporary pressure of environment, and he should be capable of resisting the fatigue that results from protracted concentration. He should be intensely alert to the possible complications latent in any problem—at the same time he should continually strive to see every situation with judicial impartiality. At no time should his judgment be influenced by any pressure, however seemingly justified, that might be brought to bear upon him. Such qualities are indispensable; for on their presence depend

the accuracy and success of his analysis. Only those capable of long periods of complete self-control should be considered eligible as candidates for the work of analyst.

Because his work demands so close an adjustment of mind and body the analyst should guard against the appearance of any slump which might lessen his efficiency. Medical science today offers safeguards against the inroads of forces that might, by being ignored or remaining unrecognized, do much physical and mental damage, and the analyst should avail himself of these scientific preventions of depletion in order to maintain his efficiency at the highest pitch. In his daily work he should also take positive methods to eliminate any manifestation that lessens the clear-cut balance which should characterize his handling of any problem.

Tact

Tact, as the term is here used, may be defined as the ability to deal successfully with all classes of men—from executives to foreign laborers—and to inspire their co-operation. The word is not employed in this connection in the sense of a suave manner, an absence of sharp corners, and a tendency to compromise. The analyst must have the courage to see things through and to face any resulting unpleasantness, but he should also be able to deal with the management and the men in such a way as to reduce such unpleasantness to a minimum.

Tact is the outcome of the right combination of all other qualities. In the right sort of man it is the result of development and training. The analyst needs continually to call tact into use in the solution of complicated problems. Such a case is well illustrated by a situation that occurred in the clothing industry of a large Eastern city where the manufacturers had formed an association to deal collectively with the union.

The labor manager retained by the association had had experience both in unscientifically managed shops and in shops

operating under scientific management. His first move, after organizing his department, was to establish some kind of working agreement about wages, conditions of work, hours and overtime, which would be mutually acceptable to the members of the association and to the union. This task seemed almost hopeless, for neither side had any facts to back up its contentions—only theories regarding the wages to be paid for work of each kind, based on general impressions of what constituted a good day's work.

Finding the situation almost hopelessly involved, the labor manager brought up at one of the first meetings of the association the need of job standardization. He suggested retaining the services of an analyst who should determine the facts which they must have if they ever hoped to meet the competition of other markets. The association became very much interested in the idea, but could not get together as a whole to retain the services of an analyst to do this work, which was such a new departure for them. The analyst succeeded, however, in interesting one of their members, who had labor complications in his factory, to the point of deciding to go ahead alone. The analyst then interviewed the Union officials and obtained their assent to work along the lines laid out by him and which were satisfactory to them.

When the assent of the union officials had been obtained the analyst called both parties into conference and outlined his plan. He explained that the first step was a diagnosis of the case. This meant an investigation of the work from the reception of the orders till the finished product left the factory—and the investigation would take several months. The manufacturer questioned the necessity for using so much time. He wanted the analyst to begin immediately to take time studies and to get the employees to work. Otherwise, he said, he was afraid that the diagnosis would benefit no one because his business seemed to him to be short-lived. In spite of all objections, however,

both sides agreed to keep their hands off and do whatever the analyst needed to make a complete diagnosis.

The investigation revealed a grave misunderstanding of the situation on the part of both manufacturer and workers. The manufacturer was convinced that the workmen were "laying down on the job," and that he was losing thereby hundreds of dollars a week. His records for 1917, 1918, 1919, showed that the cost per garment due to wages only (using 1917 as a basis) increased in 1918 by 13 per cent, in 1919 by 60 per cent, in 1920 by 140 per cent. Wages in 1920 had only increased 80 per cent since 1917. Even taking into account the fact that the style of the garment produced in 1920 was more complicated than that in 1917, the manufacturer could see no reason for the abnormally large increase in cost of making a garment over the 80 per cent increase granted in wages, except that the workmen were simply loafing on their jobs.

The union's officials and the workmen felt that the trouble was poor management. They contended that the present style of garment required more time to manufacture, though they admitted that the workmen had turned in padded production records, especially while the firm was introducing the coupon system to keep track of the quantity produced by each employee. They said that the workmen could turn out more work even with the complicated style then in use, provided the management did its part by keeping the machinery in repair, by having available necessary supplies of needles and thread, and the like. A new system of assembling garments would also increase their output. They further maintained that many rush orders were sent through and that "lot chasers" followed these orders and forced the workmen to drop their regular work and complete the rush orders, thereby cutting down the average number of garments an employee could turn out in a day.

The Analyst's Diagnosis

To make the diagnosis and prescribe the right medicine the analyst had to find out how the business was managed. Such work brought him in touch with all the routine of the office, as well as with the executives and clerks that handled it. The stock room routine and the problems of the shop came next, and at last the workmen. In making an analysis of the process of manufacture the analyst always talked to the employees. He found out what they thought about their jobs and just how much harder they found one job than another. He explained to them why he was getting the information, he asked for their opinions and assistance, and showed them that they could co-operate with the management in working out a plan which would be mutually beneficial. After this sort of investigation had been carried on for a time both sides were somewhat astonished to find how much the analyst had learned about what was actually happening in the office and the factory; they had expected that he would attempt to make radical changes on the basis of a superficial examination.

The preliminary investigation provided the opportunity the analyst needed for gaining the confidence of the employees. He realized that the union officials were only acting as the mouthpiece of the workmen. This meant that even when they saw the justice and necessity of changes, they had to convince the workmen before they could act officially. Only by gaining the confidence of the workmen first could the analyst hope for action from the union officials.

After several months of intensive work, the analyst obtained the workmen's good-will. He had not put them to any test. He had made no detailed time study of their work, and he had investigated the management methods which they believed were poor. It must be admitted that at this point the management was not so enthusiastic: it wanted to see results.

Although the analyst was ready to begin standardizing and the workmen had confidence in him, there was another difficulty to be met. The plant was only one of a large association of plants, all organized under the same union. The workmen, therefore, were afraid that the members of the union from other factories would think that by consenting to be timed they were acting as "pace-setters." Therefore, consent had to be obtained from the joint board of the union, composed of representatives from all the factories.

A union official brought up the subject at the weekly meeting of the joint board. At his suggestion a committee of three was appointed to interview the analyst and report recommendations to the board. On the following day, the union official and the analyst sat in session with this committee. After an interview of several hours in which the questions were to the point as well as comprehensive, the committee reported favorably to the joint board. The board endorsed the analyst and appointed one of the men already on the committee to appear the following Monday morning at the plant when the analyst was to begin his actual time-study work.

Winning the confidence of the union official and the workmen and obtaining the approval of the joint board were all essential. Had the analyst been unable to keep both sides in check until this was accomplished, to take time studies would have been possible, if at all, only after a long and hard fight. Although at first the extra months spent at the beginning in an attempt to educate those involved seemed expensive, the investment proved sound. Exact standards of production, making both for increased facility and decreased cost in carrying on the work, have been put into effect, and both manufacturer and union officials are ready to admit that the relations between the workmen and the management are now most satisfactory.

College Man vs. Practical Mechanic

There is always much discussion and difference of opinion as to the relative merits of the man from the shop and the college man. In time study and job analysis the technically trained college man who has several years of practical experience behind him or who has worked at a trade has a foundation that particularly fits him for the work. The recent college graduate, however, generally proves at the start a liability rather than an asset to an organization. His excess of theory and his lack of sympathy with the point of view of the workman handicap him in dealing with the practical issues that arise in the course of job standardization.

The trained college man should have:

1. Training in analysis, enabling him to break up a job into its elements.
2. An open mind unaffected by trade traditions.
3. Sufficient mechanical training to devise new equipment for the expeditious handling of work and for getting the machines to turn out greater production.

The practical mechanic has several advantages which the recent college graduate lacks, viz., practical experience, mechanical knowledge, traditional knowledge. On the other hand, he is apt to suffer from:

1. An unconscious bias due to trade traditions or personal prejudices.
2. A tendency to be overinfluenced by the ideas of his fellow workmen.
3. A lack of analytical training.
4. A lack of ability to express his ideas with sketches so as to "put them across."
5. A lack of the theoretical knowledge necessary for dealing with executives.

Either the college man or the mechanic may offer the right material for training, but the analyst cannot afford to lack any of the constructive qualities just enumerated—and least of all can he afford to lack the qualities of the executive.

Consequences of Poor Selection

In one case a client, after having developed his methods to the point where time study and job analysis would be most effective, very carefully looked over his organization for analysts and decided upon two men who had made quite a reputation for themselves in other departments. One was a chemist of exceptional ability. He seemed well qualified, since he had experience in analysis and training in scientific investigation. The other man was a machinist, who had made a reputation on his ability to take machines which had been invented and built by others but had failed to make good in actual use, and put them in such shape that they turned out even more than had been originally planned. Nevertheless, although the combination of ability had the backing of the whole organization, both men failed. The chemist lacked faith in his ability to handle the stop-watch and take the studies, while the machinist lacked and could not develop the ability to co-operate with the employees he was studying.

Position of the Analyst

Although particular instances call to an unusual degree for all the moral qualities of the analyst, especially that of tact, his position is always the same as in the case just cited—he needs to gain the confidence and co-operation of both sides. It is for this reason that exceptional qualities are demanded and a high ideal is set for him.

CHAPTER VI

NON-INTENSIVE COURSE IN TRAINING PERSONNEL

Developing Qualified Personnel

It is important to develop in the members of the time study and job analysis staff the qualities required by the analyst. Fortunately, the organization of the staff itself affords opportunities of testing out and developing would-be analysts.

The usual method of training the personnel of the staff is to combine instruction and actual work. This method has been inevitable, partly because job standardization has been so new that its own methods were still unstandardized, and even more because executives insisted upon immediate results. The average executive cannot reconcile himself to postponing results while a staff is being organized, which usually means from three to six months, even though proper training will, in the long run, save time. The necessity of getting immediate results means that the training suffers by being modified to conform to daily demands. Such a training is somewhat crude, since it cannot be intensive, and it is general instead of detailed in character. Nevertheless, by directing the men carefully and making the most of every opportunity to teach them the method and principles of their work, the experienced analyst from an "outside" specialist concern can develop a staff even by this haphazard, non-technical method.

Organization of Staff

The general lines on which the staff is organized are similar for all plants, irrespective of their size. The typical plant

is comparatively small (employing less than 1,000 people). Even in a large plant job standardization is usually started on a small scale, and it is only as the results prove valuable that the staff is enlarged. The growth is thus often a matter of gradual accretion. Whenever the need becomes especially urgent, or a promising candidate presents himself, the manager of a plant will add a man to the job standardization staff—perhaps a clerk who is not expected to pass beyond the routine stage, a particularly promising man from the shop, or a college graduate who "wants to learn the business."

The fact that job standardization requires a number of people to do the elementary work makes it practicable to begin with a number of aspirants who apparently possess the necessary qualifications. Some of them may act as "clerks" for figuring and routine work. The best of these are soon promoted to be "assistants," who determine standards under the close supervision of the analyst. A promising man may act as assistant practically from the start. It is from the assistant group that the man is trained to take over the duties of the analyst.

This ladder-like plan of organization lends itself readily to the efforts of the outside analyst who wants not only to make the department serve as a rough substitute for a training school, but also as a foundation from which he may direct the work of standardization. Although the results of combining the two processes—determining standards and training men to be capable of determining standards—are not ideal, they are reasonably adequate to the demands of the situation.

Breaking in the Novice

Too often the new assistant is let loose, as it were, in the factory and expected to become acquainted with the department, the employees, the operations, and a stop-watch all at once. In his bewilderment he wastes time and effort trying to do

work which is far in excess of his capabilities. It is more economical in the end to break in the novice gradually. Instead of being hurled in head first, to sink or swim, he should be given work which he is able to do and so be led by degrees to more responsible and practical work. The man in charge of the department should lay out a simple, graduated program for him to follow during the first few weeks of his work so that this time will serve him as a training period. A course of study, similar to the one below, followed during the first month will make the work of the novice, during the second month, valuable to the company that employs him.

1. Unless he has already served his term in the clerical group, he should be given practice in figuring time-study sheets. Computing time-study sheets shows the novice what it means to take readings of the stop-watch continuously and the method of filling the note sheet. In addition, it gives him practice in one part of his work, viz., making extensions. Accordingly, the first step in the training is to have the novice compute the time-study sheets of other observers.

2. He should also be taught to use the slide rule. Until he is familiar with its use, the analyst will give him a series of examples, graded in difficulty, such as those given in Chapter VII.

3. He should familiarize himself with the use of the decimal stop-watch. He should also be taught to take readings without stopping the watch.

4. Before going into the factory he should be able to use the stop-watch without difficulty. Office work provides many opportunities for time study. There he may take simple over-all studies, recording only the times of starting and stopping an operation.

5. He should next take similar simple over-all studies in the factory. The first operations on which he will time for practice should be:

(a) Drilling holes in bolts
(b) Loading or unloading cars of material
(c) Filling and nailing up cases

6. He should next be given practice in working up time studies—that is, he should carry out the entire routine of making a time study. After taking each time study he should make the extensions and tabulations, and plot the curves showing the times taken under different conditions.

7. The next step is to take time studies of operations divided into parts or elements. He should first divide the operation into two parts. For example, in drilling a bolt the division would be:

(a) Time drilling hole. (Element starts as soon as bolt is placed in machine, and is finished when the drill is lifted.)
(b) Time getting bolt ready to drill. (This includes putting bolt just drilled in tray at right of machine, picking up next bolt from tray at left of machine, and placing it ready to drill hole.)

8. He should now practice taking time studies in which the operation is divided into smaller and smaller elements. He should, however, not yet attempt to break up any operation into elements that require less than 0.25 or one quarter of a minute to perform. He should always work his data up completely—with curves and tables—for one job before he undertakes another that is more complicated. This practice in taking and working up elementary time studies should be continued until the novice can take readings without difficulty.

9. During this training period books and periodicals containing discussions of industrial management problems should be assigned for reading outside of working hours. Written reviews of all books read should be handed in for criticism and discussion with the analyst.

After about two months of this training it is advisable to throw away all of the time studies, notes, and tabulations taken to date, because inaccuracies make them practically valueless, and start the assistant with a clean slate.

Directing the Assistants

For a long time after this short breaking-in period is over and the assistant is capable of doing work of practical value, the analyst should direct his work and supervise each step closely.

The analyst should decide upon the operation on which it is advisable for the assistant to begin. He himself will make a brief preliminary survey of it in order to lay out the general method of attack, suggest what appear to be the principle factors, analyze the causes of variation, and so on. This will put the assistant in a position to take and work up a number of detail studies, of a more or less routine character. When these are in shape, the analyst will go over them with the assistant, helping him to draw conclusions and make plans for further study.

The assistant will present suggestions for changes to the analyst. If these prove really to constitute improvements, the analyst will take them up with the management and see that they are acted upon.

When enough studies are taken, the assistant will be allowed to establish tentative standards; but these will be checked and the final standards determined by the analyst, who tells him how to put them into shape.

The work of applying the standards is done almost entirely by the analyst, since it requires more tact than can be expected of the assistant.

As the assistant becomes more and more experienced, however, this close supervision is gradually withdrawn, until he may be said to have graduated from the training school and be a regular working member of the staff.

Learning from Mistakes

Errors, however, are always being made. Instead of allowing each novice to make again the mistakes of his predecessor, the analyst, who takes his duties of instructor seriously, sees that all the members learn from the mistakes of each one. This is a matter to which the head of any department must give a great deal of thought. Whenever an error is committed, the analyst should call the attention of the staff to its far-reaching effects showing the principles involved so that neither it nor a similar mistake will be made by the department a second time.

The Ten Don't Commandments

In this connection it has been found advisable to provide the novice with certain warnings against the most common pitfalls. These were gathered together under the heading of the "Ten Don't Commandments." While it is true that instructions should usually be given in positive terms, it may not be amiss for once to list a number of items in negative terms. These items cover the besetting sins of the novice.

1. *Don't* forget or get careless in using the decimal point either when taking the time study or when working it up.

	Correct Way				Wrong Way		
Sy.	Read.	Ex.	Notes	Sy.	Read.	Ex.	Notes
	0.00						
a	.07	0.07		a	7	7	
b	.09	0.02		b	9	2	
c	.16	0.07		c	16	7	
d	.94	0.78		d	94	78	
a	1.03	0.09		a	103	9	
b	.06	0.03		b	6	3	
c	.12	0.06		c	12	6	
d	.85	0.73		d	85	73	
a	.92	0.07		a	92	7	
b	2.04	0.12		b	4	12	
c	3.02	0.98		c	2	98	
d	.82	0.80		d	82	80	
x	6.83	3.01		x	683	301	
a	.93	0.10		a	93	10	
y	11.94	5.01		y	1194	501	

2. *Don't* fail to enter the minutes often enough to make it evident at a glance how many minutes have elapsed at any given point. This will prevent the danger of dropping a minute through carelessness.

3. *Don't* fail to enter every possible note and dimension on the time-study sheet which may have any bearing on time or manner of doing the work. Where possible get a sample of the article being time studied. Many a study is found worthless due to the failure to record some apparently minor dimension.

4. *Don't* get directly in front of the employee on whom you are taking studies or so close to him that you almost knock elbows.

5. *Don't* use the back of a time-study sheet or scrap of paper for notes or tabulations. Do the figuring on the face of the sheet or a sheet securely attached to the original.

6. *Don't* consider that simply recording what the employees actually do and averaging these times is doing time study and job analysis work. The results from this mistaken viewpoint are little better than the old piece rates set by a foreman on a good guess.

7. *Don't* jump at half baked conclusions. Keep your own council and check and recheck your conclusions before submitting them.

8. *Don't* recommend a wage payment plan without considering the effect it will have on the entire plant. Company policy is established when the first standards are put into effect.

9. *Don't* think your part of time study and job analysis is finished when the standards are determined. No matter how accurate the standards are, if you cannot get the employees to accomplish the work within the standard time, they are of little value.

10. Above all, *don't* convey the idea to the employees that you are the clever chap who is going to show them how they should do their work.

Recent Development of Intensive Training Courses

The somewhat crude training provided within the organization, as described in this chapter, has proved under most con-

ditions fairly satisfactory. The analyst who is facing the problem of developing his assistants personally may find help and inspiration in visiting a plant which has established a training course, or a university having a course, and adapting its methods to his own limited facilities. Any such course, however, must be supplemented by practical work.

It is only within the past few years that more intensive training courses were thought possible and successfully developed by the author. The non-intensive method of training men for job standardization was due to two major facts: (1) job standardization was in the first stages of development, and each new candidate was instructed by word of mouth; (2) the officials of companies were not educated as to the importance and value of job standardization.

Period of Development

During the period when job standardization was being developed each analyst was so engrossed in actually working out and applying methods that he did not take the time to put the result of his practice into tangible form. Each new man starting on this work was initiated in the easiest way—that is, by assigning him the very simplest clerical work of making extensions and tabulations of the studies taken by an experienced analyst. The novice was then given, from time to time, such information as the analyst thought necessary to stimulate him to do his work intelligently as he advanced step by step. As the work progressed, the author realized more and more the tremendous waste of time, to say nothing of the more or less unsatisfactory results of trying to give each new student all the points he should have to perform his task properly. Moreover, without a manual of some kind there was no way of coming to an agreement among the men, and each one started working along different lines and talked a different language. The attempt to standardize the standardizing

of work is embodied in this volume on job standardization.

Educating Executives

Every executive has heard of remedies proclaimed as business panaceas. To some who know job standardization scarcely more than by name it is but another cure-all. Those who really know something about it realize that it is nothing of the kind. They know that the mere buying and application of a "prescription" by the management, or working it up in their own way is not enough. The idea of standardization must be sold as a workable program to the workmen before its value in the business can be completely demonstrated. Unlike a cure-all, job standardization does not promise sudden return to health; it works slowly. But it works systematically and completely. As executives grow to realize its value they will increasingly make organized use of it in their industries. Then the education of those being fitted to be job standardizers will cease to be non-technical and will proceed along carefully thought-out lines.

CHAPTER VII

INTENSIVE COURSE IN TRAINING PERSONNEL

Advantage of a Training Course

Although the method of training by experience is satisfactory wherever the work is carried on under the direction of an able man, it is at best very slow. Neither the aim of educating the personnel nor that of determining the standards is achieved with anything like the rapidity with which it could be accomplished were it divorced from the other. Wherever a large concern, however, adopts job standardization as a business policy covering all its departments, it is advisable to introduce a regular training course. The advantage of a systematic course of instruction is that it develops men and women for job standardization in several months. Upon completing the course they will be capable of acting as responsible assistants, whereas under ordinary methods they would need at least a year to reach this stage of efficiency. The following course in job standardization has been developed by the writer and used by large manufacturing concerns. The emphasis in this course is placed upon the routine of *time study* rather than upon the larger aspects of job analysis, for the reason that the principles of job analysis and the qualifications necessary for its conduct can be developed to greatest advantage in the factory and by experience, whereas it is feasible to lay the groundwork of the mechanics of time study chiefly in the office through definite instruction. The course consists of:

1. Instruction in the use of stop-watch and time-study sheet.

2. Instruction in the fundamentals and technique of time study by means of exercises in the office.
3. Study of the best published articles and books on the principles and methods of scientific management and subjects relating thereto.
4. Practice in use of slide rule.
5. Practice in field work.

Use of Stop-Watch

First of all the student should become familiar with his tools. As time study consists of measuring the time taken—its chief tool is the stop-watch. The type of stop-watch used, however, is somewhat different from the usual kind, being adapted to the special requirements of the work. The first step in the course is to acquaint the student with its operation and proper use.

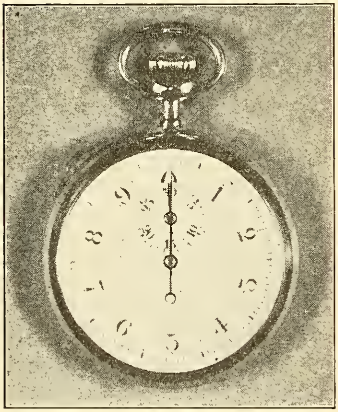


Figure 16. Single-Hand Decimal Stop-Watch

The ordinary stop-watch used in time-study work is a non-continuous movement watch—that is, the movement of the watch runs only when the large hand is in motion. The large hand may be started and stopped by moving a slide at the side. This arrangement allows the watch to be started and stopped at the will of the observer, without throwing the hand back to zero. Pressure on the top of the stem throws the hand back to zero so that the observer can commence the record of any new operation at zero. These devices give him a complete control of his watch while taking the time study.

The dial of the stop-watch, originally designed by Mr. Sanford E. Thompson, is marked off in tenths and hundredths of minutes, so that it registers the time in tenths and hundredths of minutes, instead of in minutes, seconds, and fractions of a second. One complete revolution of the large hand takes one minute. The watch has also a small hand for designating up to thirty the number of consecutive complete revolutions of the large hand. The advantage of the decimal system is that it:

1. Simplifies the recording of times, since decimals are easier to write than fractions.
2. Requires no transposition of minutes to seconds, or vice versa, which saves time in extending notes, and errors in recording and tabulating values.

The split-hand decimal timer is a modification of the ordinary type of stop-watch in that the large hand has a corresponding large hand underneath it, which can be made either to stop independently of the first large hand or to operate with it, at the will of the time-study man. The split hand is controlled by pressure at the side stem. The split-hand timer is especially useful in timing operations on which more than one employee is engaged and in timing elements of very short duration.

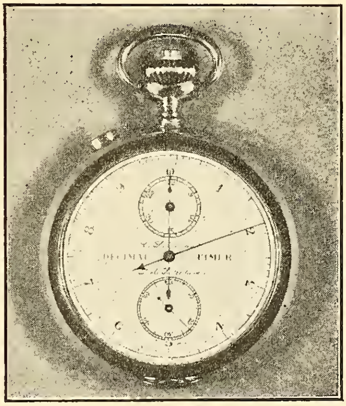


Figure 17. Split-Hand Decimal Stop-Watch

The ordinary decimal stop-watch and the split-hand watch are shown in Figures 16 and 17.

Because the stop-watch decimal dial is so unlike that of the ordinary watch dial the student will have to study it for some time before he is sure of reading it correctly. He will have

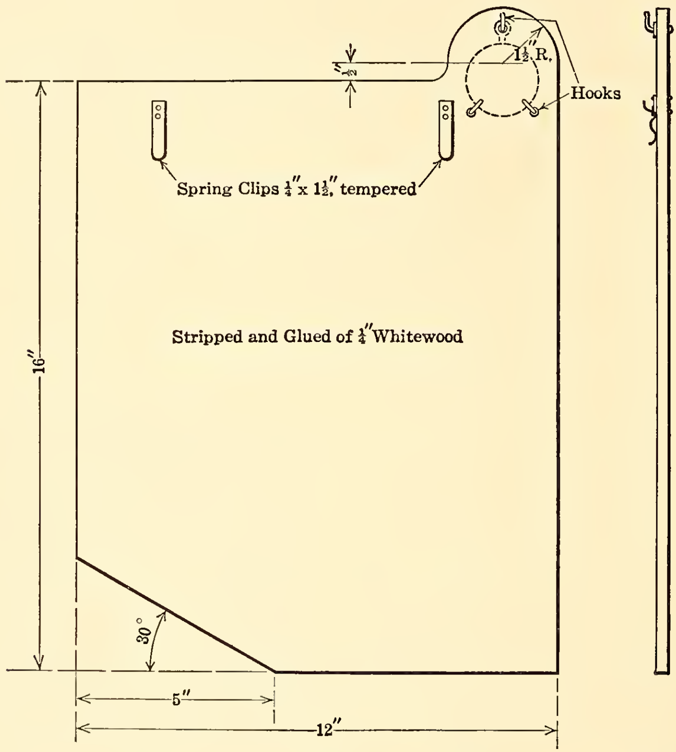


Figure 18. Line Drawing of a Regulation Time-Study Board

an opportunity of doing this while the instructor is explaining its principles. Before he is drilled in its use he should have a mental picture of the dial clearly in his mind and be able to visualize it so that he will feel no necessity of counting either forward or backward to ascertain the correct reading.

Time-Study Board

Supplementary equipment consists of a time-study board such as is reproduced in Figure 18 for holding the watch, and a standard form of sheet on which to record the readings. The method in which these are used should also be explained to the student at the beginning of the course.

The time-study board with the exposed watch and note sheets is a convenient piece of equipment, since holding the watch while taking running notes is an awkward process. The board shown in Figure 18 has several small hooks or spring clasps which hold the watch firmly in place. The note sheets also are held on the board by means of spring clips. The right hand of the observer is thereby left free to take notes.

Time-Study Sheet

Before taking time studies the student should be shown how to use the standard form of time-study sheet such as is given in Figure 19. This form insures uniformity in recording the data.

Entering the Headings

The observer should, first of all, record opposite the items at the top of the sheet the required information, which is:

Time . . . . . to . . . . . State after "time" the time of day at which the observation is begun. When the observation is completed state after "to" the time of completion.

Study Number or Symbol. This item should not be filled in until the instructor so requests.

File. Insert the filing symbol which conforms to the company's system of filing, provided there is a system.

Observer. The observer here inserts his own name or initials.

Time to
Study No. or Symbol
Observer
File
Date
Operation
Checked by

Department /

Sy	Read	Ex	Notes	Sy	Read	Ex	Notes	Sy	Read	Ex	Notes	Sy	Read	Ex	Notes

Location
Employee Rate
Implements
Materials
Conditions and Remarks

Sy. Detail Elements
a
b
c
d
e
f
g
h
i
j
k
l
m
n
o
p
q
r
s
t
u
v
w
x *Unnecessary Delays*
y *Necessary Delays*
z

Figure 19. Regulation Time-Study-Sheet

Date. Indicate here the date on which the study is made. All sheets should be numbered consecutively, viz., $10/18^1/20$; $10/18^2/20$; $10/18^3/20$. The prefix number with the date indicates the sheet number.

Operation. State here the standard name of the operation.

Checked by. This space is not to be filled in until after the study has been made.

Department. State here the building, floor number, room number, or any other definite sign of location.

Employee and Rate. State here the name, or number, and rate of pay of the employee to be studied. (Get the rate from the pay-roll department and not from the employee).

Implements. State here all tools and implements used by the employee.

Materials. State here the materials used in the operation.

Conditions and Remarks. State here all comments as to the conditions under which the work is being done. Indicate the general character of the employee's work by the words poor or good, fast or slow.

Recording the Elements

In elementary time study the operation is always analyzed into subdivisions or elements, and the observer records the time taken according to these as well as according to the operation as a whole.

After entering the necessary descriptive matter at the top of the sheet, divide the operation to be timed into its elementary units, writing these in the lower left-hand corner, one after another under the heading "Detail Elements." Should the job be long and complicated, it may be analyzed while the timing is going on and the elements entered then. The letters a, b, c, and so on, which are printed on the sheet, are to facilitate designating the elements. The letter x is to be used for "un-

necessary" delays and the letter y for "necessary" delays. The small alphabet should always be used, reserving the capitals for the purpose of making up equations or designating parts or divisions of a job.

Recording the Readings

The time of the elements is read to the nearest hundredth of a minute without stopping the watch—that is, the observer records on his sheet the watch reading at the moment the element is completed. Later on, in the office, a little figuring will give the time taken by each element separately.

All observers should use the method described whenever possible. The stop-watch times are to be recorded in the columns headed "Read." (Readings) at the top of the right-hand half of the form. These columns are the only place on the form where stop-watch readings are to be entered. In the column headed "Sy." (Symbols) the observer should place the letters a, b, c, and so on, which designate the elements. In the column headed "Notes" any remarks which may have a bearing on the time taken by the element should be carefully recorded.

Working up the Data

As soon as each time study is completed the observer works up at once the data recorded on the sheet. The first step is to find the time taken by each element.

Having recorded the necessary data, the times for the individual elements are found by making subtractions and recording the results in the column head "Ex." (Extensions). Given the readings of four elements, the record would appear as below. The figures in the column headed "Ex." are found by substracting the time reading of the first element from that of the second, the second from the third, the third from the fourth, and so on to the end of the readings.

Sy.	Read.	Ex.	Notes
	0.00		
a	0.05	0.05	
b	0.08	0.03	
c	0.12	0.04	
d	0.17	0.05	
		0.17	

The column headed "Ex." should always be totaled to check the correctness of the extensions by the over-all time.

In calculating the average of any series of unit times, always carry out the results to three decimal places. This will make it possible to differentiate quickly any time value which is an average of a number of individual time readings from a direct reading of some one time value, which will be expressed in two decimal places, namely hundredths.

The next step in working the data recorded on the sheet is to take all the time values of one element and tabulate them under its symbol. This brings them all together so that they can be easily compared and analyzed at the convenience of the analyst. The individual times are then to be tabulated, keeping all the values of the same element together. This tabulation is made in the space at the left-hand side of the form, between the headings and the space for "Detail Elements." As rapidly as the individual times are so transferred, a vertical line is drawn in the narrow column at the left of the column marked Sy.

Graphical Presentation of Time Values

The data recorded on the time-study sheets will be for variable conditions, such as the amount of weight a man carries or the distance walked, etc. The relation existing between the time values for these different weights carried or distance walked can best be determined by graphically plotting on co-

ordinate paper the time values against the weight or distance. The student should therefore be instructed in presenting the facts graphically, and should study books on this subject.

Drill in Taking Time Studies

The next step in the course consists of a number of exercises, which are intended to train the student to take time studies accurately and rapidly and to familiarize him with methods incidental to the use of the stop-watch so far as its actual manipulation is concerned. This step is most important. The first requirement of a time study is that it be absolutely accurate, as a study whose accuracy is subject to suspicion, is without value and unless the man taking it is adept in reading the watch and noting the readings even for motions that follow each other with extreme rapidity, the accuracy of a study will be doubtful.

Both instructor and student should be provided with proper equipment for the exercise as follows:

Instructor:

- One blackboard
- One deck ordinary playing cards
- One decimal timer (preferably a split-hand timer)

Students:

- One time-study board
- Fifty time-study sheets
- One fountain pen or 4H pencil
- One decimal timer

Exercises

The series of exercises in the use of the stop-watch given below is so designed as to lead the student through increasingly complicated stages until he is finally alert enough to make an independent detail study without a great deal of coaching from the instructor.

In order that the instructor may gage the accuracy of the work done by the students and in order that the students may gage the correctness of their own work, the actual readings of each of the students are called off to the instructor one by one and entered in a column under the students' names on the blackboard. This gives a basis for comparing and grading the readings of each of the students. The instructor should also keep a daily record of each student's rating. From these ratings he can establish a record of progress which can be used effectively for laying out the special work needed to bolster up the individual student whose work seems inefficient in some particular.

The first exercise, given immediately after the students are able to read the stop-watch dial and the time-study sheet, provides practice in recording individual times from hearing. The advantage of such an exercise is that while all their attention is still required for the unfamiliar act of reading the watch, the fact that they can tell the start and finish of the operation from the sound relieves them of any necessity of keeping their eyes on the operation as well.

1. *Taking Readings by Hearing, Stopping Watch for Each Reading.* The instructor takes a deck of playing cards and performs the operation of shuffling the deck of cards for the students to time. He denotes the beginning and ending of the operation by a sharp rap with the cards on the desk. Students are not to watch the instructor but to rely on their sense of *hearing* to catch the starting and stopping times. They are to start the watch at the given signal, by releasing the slide, and stop it with this slide when hearing the second signal. They are then to record the *individual* time on the time-study sheet and snap the hand back to 0 ready for the next cycle.

2. *Taking Readings by Hearing, without Stopping Watch.* This exercise is the same as number 1 except that

the student is to record his readings as continuous times. That is, he is to start the watch with the slide when the instructor starts the exercise—a series of shuffling operations—and not stop the watch till the instructor denotes the end of the exercise. While the watch is going the students, upon each tap by the instructor, denoting the completion of the operation, will make a reading and enter this reading on the time-study sheet. After the instructor has finished going through a series of exercises such as those just described the students then work up their time-study readings by subtracting one watch reading from another to determine the time taken by each cycle of the operation. The instructor should see that each student checks his subtractions by adding the individual times and comparing them with his over-all time.

By the time the students have reached the third exercise they should be able to divide their attention between watching the operation and getting the watch reading. Accordingly the student is now expected to tell the start and finish of the operation by sight instead of by sound.

3. *Taking Readings by Watching, Stopping Watch for Each Reading.* The instructor continues to shuffle and fan the cards as in the 2 previous exercises. The starting and stopping signal, however, is given by a motion of the hands rather than by a sound. The student is to *watch* the instructor for his cues as to the beginning and ending of a cycle. The watch is to be started at the beginning of the operation and stopped at the end of the operation. The individual reading is recorded on the time-study sheet and the watch then snapped back to 0.

4. *Taking Readings by Watching, without Stopping Watch.* Exercise 4 is the same as exercise 3 excepting that the watch is not stopped at the end of cycle and thrown back to 0 after reading the watch. It is a development similar to that made by exercise 2 over exercise 1.

In the first 4 exercises no attempt was made to record any description of the operation. The student was merely expected to note its starting and stopping times, as either heard or seen. The exercises were in this respect like over-all time studies. In making time studies, however, it is necessary to break up an operation into its elements and to describe these by a letter, and the student should be taught to do so at this point.

5. *Taking Readings of Several Motions or Elements, Designating Them by Symbols.* The instructor will shuffle and fan the cards at random, requesting the students to designate by a letter or symbol on the time-study sheet, the element, that is, whether shuffling or fanning. The instructor shuffles the cards by cutting them, shuffling them consecutively from 1 to 10 times—that is, the first time cutting the pack in half, the second time making 3 cuts, and so on. He gives the cues by motions of his hands. He will next follow each shuffling of the cards with a fanning element occurring 3 times, then 5 times, then 7 times, then 10 times.

The next exercise provides the student with additional practice in dividing the operations into elements and timing them. Instead of two elements, however, exercise 6 includes eleven elements.

6. *Taking Reading of a Number of Elements.* The instructor in this exercise will perform the following elements:

Shuffle pack of cards 3 consecutive times.
Fan cards twice.
Lay 10 cards in one pile.
Lay 10 cards in second pile.
Lay 8 cards in third pile.
Lay 8 cards in fourth pile.
Lay 6 cards in fifth pile.
Lay 4 cards in sixth pile.
Lay 3 cards in seventh pile.
Lay 3 cards in eighth pile.
Gather cards together.

The student should first record the sequence of the movements on the time-study sheet, deciding on a definite designation or symbol to represent each of the elements. He will then record the readings of the elements. These in the first order of performance, given above, become gradually shorter and harder to record. The instructor repeats the exercise, varying the order of performance, until the student is able to note even the shortest element without difficulty. The instructor will also introduce some unnecessary or x delays, such as dropping and picking up one of the cards, to ascertain whether the students are quick to note the delay element as distinct from the others and record the time lost.

It is difficult to take accurate readings where the steps or elements follow each other with great rapidity.

The next exercise teaches the student how to take a study on an operation in which the unit times are too short for him to read separately.

7. *Continuous Times — Subdividing Steps into Groups.* The instructor will perform the steps of laying down first seven cards, then six, then five, and so forth. He will then gather them. He will also give the cues to start and to stop by a motion of the hands. He will perform the cycle as uniformly as possible, going through the eight steps: a7, a6, a5, a4, a3, a2, a1, and b. He should go through the entire series three times.

The letter "a" preceding the numeral indicates the act of laying the cards. The letter "b" indicates the act of gathering them.

The student will start the watch with the slide at the given signal, timing the series from laying down seven cards up to and including laying down one card. He should secure at least three separate observations before passing to the next step. The second observation should start with laying down six cards and should include gathering; the third step should start with laying down five cards, and should include gathering and stop

with laying down seven cards and so on. The eight equations will be as follows:

$$
\begin{array}{lllllllllll}
1. & a7 + & a6 + & a5 + & a4 + & a3 + & a2 + & a1 & & = A \\
2. & & a6 + & a5 + & a4 + & a3 + & a2 + & a1 + & b & = B \\
3. & a7 & + & a5 + & a4 + & a3 + & a2 + & a1 + & b & = C \\
4. & a7 + & a6 & + & a4 + & a3 + & a2 + & a1 + & b & = D \\
5. & a7 + & a6 + & a5 & + & a3 + & a2 + & a1 + & b & = E \\
6. & a7 + & a6 + & a5 + & a4 & + & a2 + & a1 + & b & = F \\
7. & a7 + & a6 + & a5 + & a4 + & a3 & + & a1 + & b & = G \\
8. & a7 + & a6 + & a5 + & a4 + & a3 + & a2 & + & b & = H \\
\hline
9. & 7a7 + & 7a6 + & 7a5 + & 7a4 + & 7a3 + & 7a2 + & 7a1 + & 7b & = S
\end{array}
$$

Adding the 8 equations gives equation 9.
Dividing through by 7 gives equation 10.

$$10.\ a7 + a6 + a5 + a4 + a3 + a2 + a1 + b = \frac{S}{7}$$

The next step is to find the value of each element by subtracting each equation from equation 10.

Element b

$$
\begin{array}{ll}
10. & a7 + a6 + a5 + a4 + a3 + a2 + a1 + b = \frac{S}{7} \\
1. & a7 + a6 + a5 + a4 + a3 + a2 + a1 \quad\quad = A \\
\hline
 & \qquad\qquad\qquad\qquad\qquad\qquad b = \frac{S}{7} - A
\end{array}
$$

Element a7

$$
\begin{array}{ll}
10. & a7 + a6 + a5 + a4 + a3 + a2 + a1 + b = \frac{S}{7} \\
2. & \qquad a6 + a5 + a4 + a3 + a2 + a1 + b = B \\
\hline
 & a7 \qquad\qquad\qquad\qquad\qquad\qquad = \frac{S}{7} - B
\end{array}
$$

Similarly take each equation in turn, and subtract it from equation 10.

Points of Technique

These exercises are intended not only to give the student practice in manipulating the stop-watch, but also to train him in the correct way in which to take studies. Slipshod habits once started are hard to break. Moreover even this elementary work provides the student with his first opportunity to prove his caliber. There are, in this connection, certain points which the instructor should not overlook.

The following points are to be insisted upon:

1. The watch must always be started and stopped with the slide and snapped back to 0 with the stem.

2. Notes must be recorded on the standard form, using a fountain pen or hard pencil.

3. All exercises must eventually be taken while standing, but for the first two weeks it will be advisable to alternate standing twenty minutes and sitting twenty minutes.

4. All over-all times are to be checked by the instructor, using the split-hand decimal timer.

5. The instructor should allow absolutely no deviation from the prescribed method of taking the observations as set forth in each exercise.

In exercise 5, when introducing the step of fanning the cards several times, the instructor should not call attention to the necessity of recording how many times the cards are fanned but should check up each student to see if he has grasped the point for himself.

The instructor should daily look over each man's work and note his weaknesses. He should make notes of all points that can be improved upon and call attention to them in the class, the first thing in the morning.

The instructor should bear in mind that at the end of these exercises all persons who have failed to qualify should be transferred to another course, as it is extremely unlikely that a student could fail to master these exercises and still become

a good analyst. The instructor should, therefore, observe closely each student's work and rate him daily on the basis of the quality of his work.

Reading Matter

Throughout the course, to supplement the routine the student should be given outside reading on job standardization and on scientific management. The books should be carefully chosen so as to provide the best material published on the work from as varied points of view as possible. The books should not, however, be chosen so that they will plunge the student into material that is beyond his comprehension. The following 10 books are suggested:

Brinton, W. C., Graphic Methods of Presenting Facts
Diemer, H., Industrial Organization and Management
Drury, H. B., Scientific Management
Gantt, H. L., Industrial Leadership; Work, Wages and Profits
Gilbreth, F. B., Primer of Scientific Management
Hoxey, R. F., Scientific Management and Labor
Kitson, H. D., How to Use Your Mind
Taylor, F. W., Shop Management
Thompson, C. B., Theory and Practice of Scientific Management

It is important that the books should be read carefully and critically. In order to be sure that the students are using their minds in reading and are not failing to understand the book, nor merely acquiescing in the statements made without any consideration as to their implications, each man should be asked to hand in a brief review of several pages on each book read. The instructor should then criticize each man's review. He can in this way call attention to points overlooked and suggest further reading suited to individual needs. While reading is especially valuable to the man from the shop, who often does

not know how to get information from books or how to put his ideas on paper, it is of value to all the students, because it opens up a large field of information and trains them to make use of this information critically, in addition to teaching them the principles of their work.

Using the Slide Rule

The slide rule, while not a tool peculiar to job standardization, as is the stop-watch, is one with which everyone doing such work should be familiar. There is a great deal of figuring necessary with time-study work which can be facilitated by the use of the slide rule. The course, therefore, includes lessons in its use.

Three sets of exercises are given the student for each branch of computation: multiplication, division, and proportion. Each set contains fifty examples, graded according to the skill requisite to manipulate the rule.

Slide Rule Problems
Set No. 1—Multiplication

	Answer		Answer
1. 4 × 3	12	16. 54 × 31	1674
2. 14 × 3	42	17. 201 × 21	4221
3. 24 × 3	72	18. 115 × 15	1725
4. 34 × 3	102	19. 97 × 33	3200
5. 44 × 3	132	20. 91 × 33	3000
6. 54 × 3	162	21. 109 × 190	20700
7. 64 × 3	192	22. 119 × 199	23680
8. 74 × 6	444	23. 326 × 235	76600
9. 84 × 5	420	24. 301 × 206	62000
10. 94 × 6	564	25. 421 × 206	86700
11. 115 × 5	575	26. 637 × 279	177700
12. 101 × 11	1111	27. 952 × 102	97100
13. 110 × 11	1210	28. 727 × 325	236300
14. 14 × 22	308	29. 23 × .3	6.9
15. 39 × 83	3237	30. 76 × .8	60.8

		Answer			Answer
31.	31 × 2.5	77.5	41.	1.87 × .32	0.598
32.	64 × 2.1	134.4	42.	3.58 × .56	2.005
33.	75 × 5.6	420	43.	2.28 × 3.16	7.2
34.	213 × .2	42.6	44.	8.69 × 4.17	36.24
35.	567 × .4	227	45.	18.72 × 13.21	247.5
36.	187 × 23.6	4413	46.	1.01 × 11.10	11.2
37.	683 × 32.7	22330	47.	1327 × .53	703.3
38.	13.31 × 33	439	48.	.03 × 101.3	3.04
39.	.22 × .31	0.0682	49.	.98 × 101	99.00
40.	.68 × .46	0.3128	50.	7508 × 455.3	3,418,000

Slide Rule Problems
Set No. 2—Division

		Answer			Answer
1.	$\frac{310}{15}$	20.67	11.	$\frac{341}{94}$	3.63
2.	$\frac{325}{60}$	5.42	12.	$\frac{413}{51}$	8.10
3.	$\frac{345}{72}$	4.80	13.	$\frac{514}{41}$	12.55
4.	$\frac{311}{11}$	28.30	14.	$\frac{641}{97}$	6.61
5.	$\frac{367}{25}$	14.7	15.	$\frac{587}{33}$	17.80
6.	$\frac{430}{13}$	33.05	16.	$\frac{641}{72}$	8.90
7.	$\frac{495}{14}$	35.39	17.	$\frac{685}{96}$	7.14
8.	$\frac{395}{86}$	4.60	18.	$\frac{741}{86}$	8.64
9.	$\frac{341}{76}$	4.49	19.	$\frac{682}{39}$	17.50
10.	$\frac{411}{8}$	51.5	20.	$\frac{631}{65}$	9.70

Slide Rule Problems—*Continued*

Set No. 2—Division

	Answer		Answer
21. $\frac{687}{14}$	49.10	36. $\frac{1025.5}{10.5}$	97.75
22. $\frac{742}{12}$	61.95	37. $\frac{943}{23}$	41.00
23. $\frac{721}{32}$	22.55	38. $\frac{847}{5.4}$	157.00
24. $\frac{649}{21}$	30.85	39. $\frac{947}{25.5}$	37.18
25. $\frac{742}{124}$	5.99	40. $\frac{845.4}{61}$	13.86
26. $\frac{1242}{7}$	177.90	41. $\frac{648.4}{2.5}$	259.60
27. $\frac{1035}{9}$	115.00	42. $\frac{6845}{4}$	1710.00
28. $\frac{25.5}{4}$	6.38	43. $\frac{545}{6.3}$	86.50
29. $\frac{145.9}{8}$	18.25	44. $\frac{847}{2.55}$	332.40
30. $\frac{245.9}{8}$	30.75	45. $\frac{679.5}{25}$	27.20
31. $\frac{245.6}{2.5}$	98.25	46. $\frac{875}{125}$	7.00
32. $\frac{458}{9.6}$	47.75	47. $\frac{643}{61}$	10.54
33. $\frac{872.5}{4.5}$	194.00	48. $\frac{958}{68}$	14.10
34. $\frac{943}{8.7}$	108.40	49. $\frac{943.4}{25}$	37.70
35. $\frac{845.6}{94}$	9.00	50. $\frac{899.1}{2.1}$	428.50

Slide Rule Problems
Set No. 3—Proportion

	Problem	Answer		Problem	Answer
1.	$\frac{.11}{.32} : \frac{.26}{X}$	0.755	16.	$\frac{.42}{.37} : \frac{X}{.53}$	60.15
2.	$\frac{.17}{.23} : \frac{.36}{X}$	0.487	17.	$\frac{.03}{.72} : \frac{X}{4.1}$	0.171
3.	$\frac{.36}{.17} : \frac{.28}{X}$	0.1321	18.	$\frac{.18}{.03} : \frac{X}{9.2}$	55.20
4.	$\frac{4.2}{.7} : \frac{.21}{X}$	0.0355	19.	$\frac{2.3}{.09} : \frac{X}{41}$	1048.00
5.	$\frac{.87}{9.4} : \frac{4.3}{X}$	46.5	20.	$\frac{.73}{.91} : \frac{X}{12}$	9.63
6.	$\frac{.18}{.32} : \frac{4.5}{X}$	8.0	21.	$\frac{4.3}{9.6} : \frac{X}{41}$	18.36
7.	$\frac{9.3}{.67} : \frac{.32}{X}$	0.023	22.	$\frac{.08}{4.2} : \frac{X}{.17}$	0.00324
8.	$\frac{.73}{3.6} : \frac{5.8}{X}$	28.60	23.	$\frac{4.9}{6.3} : \frac{X}{27}$	21.00
9.	$\frac{.07}{38} : \frac{41}{X}$	22,250.00	24.	$\frac{.03}{1.8} : \frac{X}{2.8}$	0.0467
10.	$\frac{.03}{4.2} : \frac{3.9}{X}$	546.00	25.	$\frac{9.6}{.18} : \frac{X}{2.9}$	154.50
11.	$\frac{.13}{48} : \frac{X}{93}$	0.252	26.	$\frac{123}{241} : \frac{263}{X}$	515.00
12.	$\frac{.23}{.67} : \frac{X}{.17}$	0.0584	27.	$\frac{361}{128} : \frac{235}{X}$	83.30
13.	$\frac{.73}{.42} : \frac{X}{19}$	33.00	28.	$\frac{345}{409} : \frac{556}{X}$	659.00
14.	$\frac{9.3}{4.8} : \frac{X}{.13}$	0.252	29.	$\frac{109}{225} : \frac{150}{X}$	310.00
15.	$\frac{7.2}{.81} : \frac{X}{.43}$	3.82	30.	$\frac{203}{420} : \frac{X}{355}$	171.50

Slide Rule Problems—*Continued*

Set No. 3—Proportion

		Answer
31.	$\frac{350}{525} : \frac{279}{X}$	419.00
32.	$\frac{421}{368} : \frac{215}{X}$	188.00
33.	$\frac{263}{488} : \frac{110}{X}$	204.10
34.	$\frac{768}{324} : \frac{847}{X}$	357.00
35.	$\frac{382}{141} : \frac{409}{X}$	151.00
36.	$\frac{432}{361} : \frac{517}{X}$	432.00
37.	$\frac{410}{525} : \frac{362}{X}$	464.00
38.	$\frac{721}{849} : \frac{533}{X}$	628.00
39.	$\frac{438}{509} : \frac{621}{X}$	721.50
40.	$\frac{386}{721} : \frac{101}{X}$	189.00
41.	$\frac{182}{364} : \frac{X}{404}$	202.00
42.	$\frac{362}{178} : \frac{X}{510}$	1038.00
43.	$\frac{421}{362} : \frac{X}{609}$	708.00
44.	$\frac{526}{809} : \frac{X}{628}$	408.50
45.	$\frac{708}{326} : \frac{X}{201}$	436.00
46.	$\frac{523}{721} : \frac{X}{685}$	497.00
47.	$\frac{680}{749} : \frac{X}{585}$	531.00
48.	$\frac{498}{655} : \frac{X}{728}$	554.00
49.	$\frac{468}{507} : \frac{X}{368}$	339.50
50.	$\frac{645}{701} : \frac{X}{558}$	513.50

When the student can readily read off the answers to all of these problems he should be able to take advantage of the slide rule in making any computations incidental to his work.

Field Work

The student should now be ready for the field work of the course—that is, the taking of studies in the factory itself and under actual conditions. All the work hitherto—the exer-

cises in the use of stop-watch and slide rule, as well as the supplementary reading—has been done in the office under artificial conditions. Its purpose has been to give the student the necessary background and drill him until he acquired the necessary dexterity. Especially the exercises in the use of the stop-watch should have so accustomed him to its working mechanism as to enable him to concentrate on observing the operation and workman with some degree of confidence in his ability to make and record his observations accurately and rapidly. When he has reached this stage he should be given his first experience in actual field work.

The taking of time studies in the factory differs in some respects from the taking of time studies in carefully planned exercises where the instructor acts as operator and regulates his pace according to the capacity of the observers. Some of the differences may be pointed out at the start. Others may only be found in practice, as the student learns to adapt himself to the pace of the operator and to note immediately the use of an unforeseen motion.

The recording of the readings requires close attention on the part of the unpracticed observer. On this account the early studies should be short, otherwise the novice becomes too tired to work accurately. Taking the studies should be alternated with working them up in the office. A number of studies should be taken on the same operation. Such a practice is more satisfactory than taking studies on several different operations, since the student becomes familiar with the peculiarities of the particular job he is studying and is better able to check and correct his earlier errors.

Final Tabulations

After the instructor is satisfied that enough studies have been taken on the one operation, the student should be allowed to tabulate the results for the purpose of comparison. In actual

job standardization this is the last step before determining the standard times, viz., listing the conclusions of each study, in order that the final conclusions may be drawn from the results of all the studies. While the student is not required to draw full conclusions, the bringing together of all his separate tabulations gives him a clearer idea of the point to which his studies have been leading him. He can then compare the variation in the total operation times with the unit times of the elements

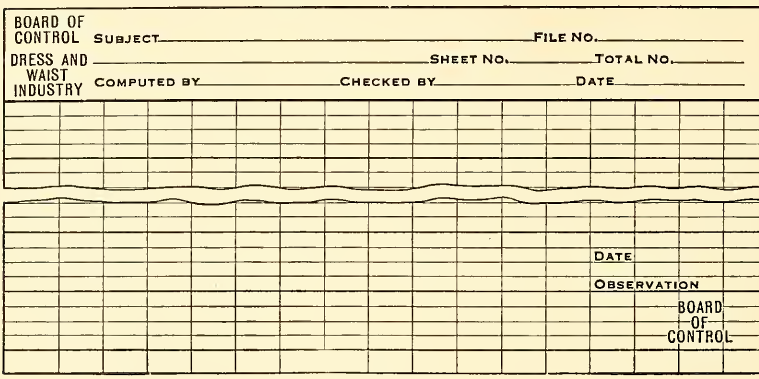


Figure 20. Regulation Final Tabulation Sheet

for each study, and analyze the causes of this variation. If they are caused by the "job" or the individual order, such as peculiarity in the pattern or the leather in a shoe, he should make a record of the cause and state the amount of the variation. The final tabulation constitutes a summary of the results of both the field and office work.

The sheets for final tabulation are specially ruled and contain spaces for the time found after figuring the study. On the tabulation sheet are listed: the unit times of the operation; the total times of the operation; the percentage of delays; the variables affecting the operation, and all explanatory notes as indicated on the original time-study sheets.

Under the direction of the instructor the student should tabulate, on such a sheet as is shown in Figure 20, the values he has recorded. On this sheet the results taken from the time-study sheet are brought together in organized form.

The summarizing of field and office work should be continued on as many operations as the instructor feels will be valuable to the student. When this point is reached the student is ready to be graduated from the course and given a position on the staff as a regular assistant.

Wherever there is so much to be accomplished that many assistants are required and the work is likely to extend over a long period of time, a course of this sort will prove economical. Not only does it reduce the length of the training period, but it has two further advantages perhaps even more to be desired —it relieves the head of the department from the task of instruction and creates a staff whose standards are uniform. The analyst in a plant where such a plan is impracticable can find many features of the course—such, for example, as the exercises—which will be valuable to him in his attempt to develop a working staff.

This intensive course of training was originally developed for the United States Rubber Company at their Lycoming plant, Williamsport, Penn. Since then a number of companies have undertaken the course with great success, one of these being the H. H. Franklin Manufacturing Company of Syracuse, N. Y. Here the students were not novices, but they had *not* been trained in the methods conducive to obtain best results. The course brought about a unification of methods based on facts instead of individual judgment, as formerly. Furthermore, it made possible the standardization of the color varnishing operation which is one of the most exacting in automobile manufacture.

CHAPTER VIII

ENLISTING CO-OPERATION

The Analyst's Problem

The previous chapters have discussed the necessary qualities and training of persons who are to work out time studies and job analyses. And for the purpose of giving a comprehensive view of the field, the way in which they are to follow out their training has also been briefly outlined. In this and the following chapters what they are to do is described in detail. In a word, these chapters are intended to serve as a guide to those acting in the capacity of analysts.

Necessity of Co-operation in Business

First of all the analyst should attempt to gain the cordial co-operation of all those affected by the conduct of analysis. Co-operation is necessary in undertaking any new policy or process in which a large number of people are concerned. The more intimate their concern, the more profoundly can they affect the policy. If forced to accept something in which they do not believe they will either consciously or unconsciously do their best to prove that it was wrong. People cannot be driven, they will never go far unless they are led. What is wanted in carrying out a new process is not mere surface acquiescence, but active interest.

Job Standardization a Co-operative Undertaking

The necessity of gaining the cordial co-operation of all concerned is even more marked in time study and job analysis than it is in introducing most innovations, because it is carried

on directly with and through those in an organization from lowest to highest. It gathers together, moreover, all the impressions, traditions, and suggestions which have grown up in the shop, and which are the sum of the knowledge of a generation of workmen, both foremen and employees. All these it is obliged to compare, check, and supplement in the light of the knowledge which the analyst gains by his detailed observations.

It has been a popular impression that, because industrial engineers are concentrating on making the organization as a whole function with the efficiency of a perfectly constructed machine, they look upon the members of the organization merely as the component parts of such a machine—in other words, that they are trying to turn human beings into machines. Dr. Royal Meeker expressed this point of view in an address before the American Economic Association.

> The scientific managers have been attacked so violently and so frequently that I feel obliged to apologize for referring at this point to the most obvious and fundamental error contained in their original program. The scientific managers did not, in the beginning of the efficiency movement, differentiate between the workman and the machine or tool with which he worked. Men and machines were to be made to do each operation the easiest way; that is, with the least lost motion and expenditure of effort. The scientific managers have not yet grasped fully the difference between a man and machine and the economy of making use of the heads of the workers as well as their arms and legs.[1]

In the beginning some analysts perhaps attempted to work along these lines. The attempt defeated its own purpose. Unless job standardization is carried out as a development in which both employees and executives are educated to co-operate it cannot be fully successful and will not result in mutual benefit.

[1] *Monthly Labor Review*, February, 1920.

Preliminaries of Co-operation

At this point the analyst must direct his attention chiefly to enlisting the co-operation of the superintendent and the foremen. It is assumed that by retaining the analyst the management has expressed its confidence in job standardization and has adopted standardization methods as a business policy. The manager of manufacturing, sometimes designated as the works manager, the general manager, or the agent, is the man who controls the policies of the plant and represents the management in the manufacturing end of the enterprise. If this man, as is sometimes the case, fails to recognize the desirability of the policy adopted by the board of directors, or considers this policy a personal reflection upon his ability, and so maintains a neutral attitude, it is very difficult for the analyst to hope to enlist the co-operation of those lower in rank, for the attitude of the man in charge permeates the entire organization.

This fact was illustrated very forcibly in a large manufacturing plant where the officials of the company became interested in scientific management and retained an expert to instal the system in their plant. The manager of manufacturing was, of course, consulted, but having worked himself up from the bottom he did not see how any outsider could understand the work. Nevertheless, he thought if the officials decided that the work should be done, he would not stand in the way of their benefitting as much as possible by the change. Although the first operation to be standardized was comparatively simple, remaining practically unchanged so that the standards could be developed readily, and affected only one machine and two operatives, it took nearly six months of endeavor on the part of the analyst to make the standards on this machine effective. It seemed as though every conceivable complication arose during this period to prove that the standards could not be met, although in the end persistent work won the day.

Several years later the manager of manufacturing faced a serious problem of increasing production on the most important of all the operations in the plant. If he could not meet it he would have to buy more machinery and build to accommodate the increase. In this emergency the results of standardization appealed to him, and he induced the company to retain the analyst who had done the first job. The second task was the most difficult the analyst had ever come across in all his years of practice, and it required some months of intensive work, with the aid of several assistants, to complete the studies. When everything was ready, and the first employee was about to be started on the new standards, the workmen put their heads together and decided that they would not accept them. The analyst explained the situation to the manager of manufacturing. The manager at once called into his office the first man to be started and himself told him that he had followed the work of the analyst and was convinced that the standards were correct and that if the workman went ahead according to instruction he knew he would find them so. The workman accordingly did the work and found that the standards were right, and with the knowledge that the manager of manufacturing was back of the standards, other workmen were started one by one without the slightest objection.

Employees and the Preliminary Campaign

The employees or "operatives" are not considered in this preliminary campaign for enlisting co-operation. The attitude of the employees at the outset is almost always determined by the attitude of the superintendent and the foreman. Winning over the superintendent and foreman means enlisting the interest of the employees, at least in part, except in cases where the employees are highly organized in unions sufficiently strong to have a voice in determining policy. The employees must be won over by the attitude of the analyst during the time he

is actually making the studies and is in close contact with them. Their good-will and friendship will be tested when he is applying the standards, at which time he will work most intimately with them.

The work of the analyst in this preliminary step, accordingly, centers upon two people, the superintendent and the foreman.

Winning the Superintendent

When a change is being introduced, it should be in every case through the natural channels of authority. The process superintendent represents the authority in the factory. He is the power with which the foremen come in contact, and he stands to them for the conservative, well-established source of control. They will listen to what he has to say when they would look upon a stranger with suspicion. If his faith in job standardization is shaky, theirs will be still more so, but if his faith is strong it will serve to dispel their doubt. An able superintendent who comes to realize the value of time study can be depended upon to get the idea across to the foremen, and through the foremen to the workmen.

Before starting even the preliminaries of job standardization the analyst should therefore hold a conference with the superintendent in order to explain to him fully the principles and practice of the work. This conference should be held when possible in the superintendent's office, or in any place which seems suitable, except the factory. If it is held in the factory the conversation is likely to be overheard by the workmen, and may possibly be misconstrued.

Points for Superintendent

Although what is said in the conference must obviously be adapted to the personality and peculiar interests of the particular man, there are some points which the nature of his

position cannot fail to make of interest to him. The points which should be brought out in conference are:

1. How to discover the best methods of production.
2. How to get on an equitable basis of wage payment.

Methods of Production

In order to convince the superintendent that study is desirable in "his" factory so as to work out a complete plan for the best method of turning out the product, the following points may be brought to his attention:

1. In every business detailed study is necessary to find the best method of operating.
2. The best method can be found by analyzing each operation as performed by the different employees.
3. The best layout for each job can also be found only by detailed analysis.
4. The foreman does not know what are the best methods because he has neither the time nor the *facts*.

The best method of performing each operation—i.e., the method which requires the minimum of energy and material—can be determined only by detailed study. An observation of other concerns shows that there is great variation in the output of the workman, and this is probably due in large part to a lack of any systematic plan. So long as the concern has no idea of its cause or cure, the variation in output is sure to continue, regardless of whether the employees are on piece or day work. The way to determine the best methods is to work up a study of each operation as it is being performed by the different employees.

The records of performance also show that some employees turn out more, or better, work than others and consequently earn more money when on piecework. Although they all appear to be doing the operation in the same way, the

appearance is deceiving. The foreman will simply explain it by saying that there are "good workers" and "poor workers" and let it go at that. But all the employees can be made better workers if the reason is found for the difference between the good and the poor. In order to do this, it is necessary to analyze in detail for a sufficiently long period of time in just what way one employee is capable of doing more work than another with no more effort, and sometimes with less.

The same sort of detailed analysis shows the best layout for each job. It may be that two operations at present done by two employees could be combined to advantage, eliminating one "picking up and laying down of the stock," and thereby saving the time and energy of the workmen and keeping the stock from becoming soiled and shopworn. On the other hand, perhaps it would be better to split the operations one step further, by keeping a separate moveman busy handling stock in the most expeditious way.

It is customary to assume that the foreman is looking after such problems; but he usually has so many immediate difficulties that he cannot spare the time necessary for detailed analysis. If we ask the foreman or the employees, we will find that, although they all have their impressions—generally, of course, in favor of the way in which the work is being handled at present—no one has any facts with which to back up an impression.

Equitable Basis of Wage Payment

The superintendent is especially concerned with the problem of wage adjustment. If the factory is largely on day work, the output is probably small. If it is on piecework, the employees are probably dissatisfied and keep asserting that the rates are unfair. As one group after another brings pressure to bear for an increase in pay, while the wages of the less militant groups remain at the old level, the whole organization

is gradually roused to a feeling of antagonism toward the management.

The trouble is that the question of an equitable adjustment of wages, is, like everything else, left to opinion. In a factory making coats, sweaters, and outside garments, the analyst found that the piecework rates on two styles of garments—style 238 (Ladies' Riding Breeches) and style 523 (Coat)—were respectively $2.64 and $12 per dozen garments. Analysis through time study and job analysis, showed that the time necessary to manufacture these two different styles of garments was practically the same; one requiring 30.2 minutes and the other 32.4.

Although this is an extreme case of the results of setting piece rates by guess, it represents in an accentuated form the sort of injustice that is being done wherever there is no careful study made of the operations entering into production.

The only way to find any just basis for a fair adjustment of pay throughout the factory is to make an analysis of the factors involved in each operation, such as experience, application, and danger involved. The relative proportions of all the factors, especially of the time factor, which is the yardstick measure of production, should be the basis in determining and paying equitable wages. This basis can be determined only by detailed analysis of each operation. Payment of equitable wages is one of the most important factors in bringing about good relations between employers and employees.

Convincing the Foreman

The superintendent is the first man who should take up the matter with the foreman of the department in which job standardization is to be introduced. He should pass on to the foreman the gist of his talk with the analyst. If the superintendent has faith in the analyst and is enthusiastic over the prospect of obtaining results, the foreman will be convinced that the

plan is not merely the notion of an office-chair theorist and will become interested in doing his own part.

It has been said that the chain of management is no stronger than its weakest foreman link. The same is true of co-operation and good-will which the management wishes to establish for job standardization. The employees will sense at once their foreman's attitude toward the new order and his attitude will be the attitude of his department.

In the finishing department of a large mill where an analyst was working, the foreman had frequently said that time study and job analysis was the best method he had ever seen and that he endorsed it without qualification. Strange to say, however, the analyst found that unless he followed every move of the workmen, which was impossible in a department of three hundred employees and some thirty different operations, they would not do the work in the standard time. When the foreman looked over the daily records with the analyst, he could, in some cases, give a reason for this or that failure, but could not understand the universally poor records. This condition continued for some time, although the analyst, the superintendent, and to all appearances the foreman, were trying to find the reason why the employees should make the standards every time they were watched, but never when free from observation. Finally the foreman made the mistake of taking a vacation, and during his absence the truth came out; although he had never actually told his workmen that they might lie down on the job whenever possible, he had shown by his manner that he hoped the standards would not work, because he wanted to reinstate the method which let him set the rates by guess, thereby being a good fellow with all his men.

Respect for Foreman's Authority

Some foremen are jealous of their authority and quick to resent the least encroachment upon it. Any modification in

the conduct of their departments, even if it is something which under past conditions they could not have been expected to attend to, is likely to appear to them as a slur on their ability, which is of course the last thing intended. On this account, their authority should be referred to wherever possible. Especially they should be assured that nothing will be done without consulting them and no order given except through them.

The Talk to Foreman

The talk with the superintendent prepares the foreman for details and instructions from the analyst. When possible, some particular operation in his own department should be pointed out to him where a detailed study might show possibilities of improvement. This is where the experience of the analyst is of extreme importance, for whether or not he has ever seen the particular machines or operations before, he will be able to point out how the type of improvement which they are talking over can actually be applied and with what results. The analyst does not make the suggestion as a fully developed workable plan, but indicates the method by which this or that idea may be tried with the result either of developing some improvements from the experiment, or of proving the existing method to be the best under the conditions.

Certain points are of more immediate concern to the foreman than to the superintendent, and these should be taken up very carefully:

1. Job standardization increases the foreman's value to the company and therefore to himself.
2. Job standardization does not interfere with production.
3. Changes will be made through the foreman.
4. Employees will be chosen with the foreman's advice and knowledge.
5. Quality standards will be maintained either by standardization or inspection.

A foreman is, in most cases, a practical workman who has shown executive ability. He is a foreman because of his knowledge and ability to instruct and represent the employees on the one hand and on the other hand to safeguard and represent the owner's interests. This dual position, no doubt, accounts in a large degree for the multiplicity of details which are shouldered on him. Under the older types of management it is the rule rather than the exception to find the foreman burdened with clerical records of timekeeping and production, together with responsibilities for hiring and firing, making minor repairs to machines, belts, and equipment, trying to get stock and materials from the department ahead in order to keep his workmen busy or trying to unload the finished work on the department following in order to make room in which to work. A few minutes reflection will show the absurdity of expecting any one man to perform this multiplicity of functions.

Under the new methods of management the work is functionalized by having the clerical part of it done by clerical specialists, the hiring and firing by the employment specialist, the repairs by the repair specialist, thus leaving to the foreman the actual directing, instructing, and developing of the workmen, so that he may get the maximum quantity and quality of work. The analyst works with the foreman in developing standards which the workman can maintain day by day and year by year.

The foreman's chief concern is to keep up production. Every foreman has learned by experience that production drops every time any change, no matter how slight, is made. What then will happen to his production if, as the analyst has probably indicated, changes are made that involve experimentation? The argument, therefore, that the studies may interfere with production is often the foreman's chief reason for objecting to the experiments. Analysts uniformly find that the process of job standardization need never reduce production; in fact,

it generally increases production even while studies are being taken, because careful observation of an employee tends to make him concentrate. Changes in the method of operating should not be made just before time studies are started because any change reduces a workman's output until he becomes accustomed to the new methods. If the preliminary study shows that the method of operating should be changed radically, then the workman should be allowed to learn the new method thoroughly before studies are started. In most cases it is not necessary even to make minor changes in the method of operating in order to try out what may seem a saving in time, for, if the studies are taken in minute detail, tied in properly with full notes (by the analyst), it is often possible to determine beforehand whether or not the change will be advisable. Such an estimate will probably prove more accurate than a study of the operation as performed according to the new method by a workman unfamiliar with the new technique.

The Foreman's Authority

Any change desired, no matter how small, should be taken up with the foreman and acted upon only through his order. Not only does this lessen the possibility of changes interfering with production, but it contributes to the foreman's authority in the room. The foreman is its sole head, and his authority is in no way superseded by the authority of the analyst. The analyst works with the foreman as well as with the employees, so that any changes which look as if they should be tried out are known to the foreman; accordingly there arises a kind of mutual interest which generally eliminates the necessity for having the foreman go to the workmen and instruct them to work under the order of the analyst. If, however, the workman should refuse to work under the analyst, it would almost invariably be found that the cause of refusal was some feeling of antagonism between the analyst and the foreman. Such a

situation, besides being uncomfortable, protracts the processes of job standardization.

The Foreman's Knowledge of Employees

The employees studied should be chosen with the knowledge and advice of the foreman. His recommendations as to the employees on whom the first studies should be taken should be given careful consideration by the analyst. Those whom a foreman calls his "best workers" may turn out not to make use of the best methods, but may be expert only because of long experience. Usually a foreman is a pretty good judge of the strong and the weak points of his workmen. Talking these points over with the foreman gives the analyst an inside track both in dealing with the workman and in making allowances for the personal equation when he works up his studies.

Maintaining Quality Standards

In most industries quality standards are not established on a basis of definiteness, but are the result of the impressions of executives and workmen. For every article, of course, there must be some standard of quality to determine acceptability, but where the demand is greater than the supply, the quality standard can be somewhat lower than when the demand is less than the supply. Even under normal conditions the quality standard fluctuates slightly from time to time, depending upon the amount of time which has elapsed since the last complaint. The foreman, having an intimate experience of these conditions, realizes that the quality factor is most important and is fearful lest any plan which is developed to induce workmen to turn out more work may cause them to overdo and lower the quality of the goods manufactured. A mechanism must be provided by the analyst to safeguard just this condition so that quality is at least maintained. In actual experience, the quality is, if anything, slightly improved.

Quality through Standardization

It is sometimes possible to devise mechanical methods of maintaining the quality, which give as good results as those obtained by employing specialized workmen at a large expense.

The operation of spraying buttons is a good illustration. The ivory buttons worn on men's and women's suits are white in their original state and are afterward dyed to match the colors of the suits. Many of these buttons are of a uniform color, generally black. These buttons are dyed in much the same way as a film is developed. Other buttons, especially those on ladies' suits, serve as much for ornament as for use, and must be made up to look more attractive than if dyed one flat tone, and are therefore shaded, mottled or worked out in elaborate designs. Fancy buttons are dyed by being sprayed with the desired colors, each shade being given a separate application of the spray. The buttons are first put in rows on a board equipped with protruding pins which go through the holes in the buttons and keep them in place. Then a stencil is placed over the buttons to give the desired pattern, and the color is applied at a uniform speed. The speed and the number of "strokes," or movements of the spray, for each row vary according to the design and the color. A stencil with wide spaces requires less number of strokes than one with narrow spaces.

In this case the analyst studied the requirements of the different colors and designs and drew up a stencil chart setting standards as to the speed with which each pattern was to be sprayed and the number of stencil strokes to the row. A metronome was used to measure the time of the strokes. The setting of definite standards for each design made it possible for the ordinary workman to do the work which had previously been done by special workmen. This plan developed all-round workmen, with the result that a reduction of the force was made possible, and a quality provided that was as good or even better than before.

Quality by Inspection

In other cases a system of inspection may be installed to guard against the employees' neglecting quality for quantity. This is specially desirable where defects can be detected at once. The result is that although production is increased, quality is not lowered. The increase in production from the introduction of exact rates will almost always be large enough to very much more than pay the wages of the inspector.

Final Effect on Foreman

If the analyst's work is well done the foreman will be convinced before long that the new plan of production standards is not a mere process of speeding up, but a means of putting into effect the best methods of performance possible under existing conditions.

The following telegram received from a foreman who had formerly been, as he states it, "bitterly opposed" to the new methods of management, shows how even the men who at first consider these methods most impractical will be won over when they see the results. This telegram was in response to a manufacturer who was skeptical of the claim that the foreman and employees could be converted to scientific management and who wanted a direct statement from a foreman. As it was felt that a letter would allow the foreman too much opportunity to conceal his true sentiments he was asked to telegraph the statement of his opinion of the new methods, which had been in effect in his factory for a period of two years.

> When the Taylor system was started at the Eastern Manufacturing Company two years ago I had been employed by the company in various capacities for eighteen years and at that time was foreman of the finishing department. I thought I knew all the best methods of handling work in my particular line and naturally resented the idea that any outsider could

come in and make any improvements in our methods. During the first year no one could have opposed the system more bitterly than I because I believed it to be an impractical, costly and almost impossible method to use in our business. I would admit that it might be used in some lines but never in the paper business.

At the present my position is production man of the finishing department. We are putting through the department at less cost at least 33 1-3 per cent more work than ever before. Our planning department is working smoothly and the work goes through the shop with scarcely a hitch. Our customers are kept satisfied because their orders are shipped on the date promised. The idea of going back to the old method would be very distasteful to both the employees and myself. The employees are better satisfied because they are earning nearly 50 per cent more money with scarcely any greater effort. I will add that you have asked me to state the case just as I feel without any prejudice for or against the system.

H. H. HACKETT.

When the superintendent and the foreman are back of the work and the employees are predisposed in its favor by the attitude of their foreman, the analyst will find that he can proceed smoothly with the actual time-study work knowing that nothing need stand in the way of complete success.

CHAPTER IX

RELATION OF PHASES IN JOB STANDARDIZATION

Time Element in Analysis

The most difficult question ever asked the analyst by the management is, "How long will it take to complete the analysis work on this or that operation?" There are always so many factors involved that any definite estimate in a particular case is extremely difficult. Discussion of the topic in generalized terms is even more difficult, inasmuch as different operations even in the same plant differ radically. It is possible, however, to note some of the variables which occur constantly and result in variation of time values, and arrive at some sort of tentative working generalization.

Both the amount of time required to make a study of one operation and the distribution of time between the four phases of the study—preliminary work, taking the times, analyzing the studies and setting the standards, and putting the standards into effect—are mainly dependent upon two factors: the experience of the analyst, and the complication of the variables.

Time and the Analyst

The competence of the analyst influences in many ways the amount of time required to make a study. The time taken depends to a large extent upon whether he is experienced or only a beginner; whether his experience covers more than the business he is studying; whether he has personal knowledge of that business; whether he is prone to work theoretically or mechanically; whether he has a far-sighted or near-sighted point of view.

Need of Experienced Analyst

Probably in no other line of business can the practical expert be distinguished so readily from the man who poses as an expert. The inexperienced man may do a great deal of talking and make a great many promises, but he is likely to attack only the high spots and risk upsetting the organization in an attempt to reach conclusions that soon prove none too sound. The trained analyst, on the contrary, plans his work so as to enlist the help of the organization in making changes of permanent value.

Experience in many lines of business is a large asset to an analyst. While it is true that every business is different, it is surprising to note the points of similarity in entirely unrelated businesses. For instance, both in making rubber shoes and in coating paper a so-called calender machine is used, and although the materials going through the machine are totally different and their ultimate purposes are different, the experience of a certain analyst in setting standards for the calender used in coating paper helped him to handle the problem of calendering rubber fabrics.

Confidence in the Analyst

The presence of the analyst in the factory shows that he has at least the good-will of the management. He must, however, have more than this—he must have their confidence. They must take his word, because they cannot expect to be able to review in detail his mass of data and check his recommendations before accepting them. Moreover the analyst, although the representative of the management and paid by them, must enjoy the confidence of superintendent, foreman and workmen. He must prove to all these men that he can be entrusted with the results of their thoughts and experiences, which have accumulated through years of practical experience, and that he will use this material for his informants' good

as well as for the good of the company. The ideal plan, of course, would be for the analyst to be employed and paid jointly by both management and workmen. It has been proved many times, however, that a man of the right training and make-up can represent adequately the workmen and their interests even though he is paid only by the management.

"Make-Up" of the Analyst

Everyone has natural inclinations and it is, therefore, not at all strange when an analyst leans too strongly to theory or to merely mechanical methods. Some analysts try to determine general standards for an operation as quickly as possible in order to get tangible results and then having applied a coarse-tooth comb they go over the proposition again with a finer comb, making, if necessary, a research to determine the very best practice possible. Other analysts are of opinion that a fine-tooth comb should be applied at the start. This choice of methods, of course, has material effect upon the time required to accomplish the work.

Variables in Standardization

A cursory examination of a given operation often is not sufficient to show exactly how much time will be required to establish the standards for a particular operation. After a number of studies have been taken they may reveal the relative unimportance of variables which at first loomed large, or on the other hand, the importance of some complication not evident at the outset. Apparently simple operations sometimes have a number of variables which are hard to determine, making necessary many more studies than had been counted upon.

Unexpected Variables

Frequently what seemed at first a simple operation is found to be quite involved, because the material which is being worked

with has no defined standards. Painting automobile bodies is a case in point. In this work perfect evenness in laying on the paint so that no excess or unevenness of the applied material shall show is so largely dependent upon the skill of the workman that to standardize the work seems almost impossible.

On some other operations the machine and tools which are being used, may be found to have so large a bearing on the situation that the analyst will have to consider the advisability of first undertaking special research. This was the case on the operation of wire drawing, where it was necessary to first invent machinery in order to make uniform dies.

Occasionally it is advisable to study the operations that precede the one under attention in order to see whether it is practicable to make changes in the division of the work. This delays for a considerable period the setting of standards on the original operation and renders worthless any previous estimate of the time required. For instance, in studying the operation of cementing the edges of one of the parts of white canvas shoes it was found, after a number of studies had been taken, that by a change in the method of cutting and assembling the pieces so as to keep all the "rights" together in one group and all the "lefts" in another instead of pairing each "right" with the corresponding "left" as had previously been the case, it would be possible to complete not only the operation under study but several of the operations following in at least 25 per cent less time. In view of the results the fact that standardizing the operation took about twice as long as given in the original estimate made little difference.

Occasionally, however, a surprise is in store for the analyst when some operation turns out to be far simpler than anyone imagined or when a certain element corresponds to others which have already been studied and the results in the one case can be applied in the others.

Infrequent Variables

Another thing which upsets all calculations as to the time required to make the studies is the fact that on some operations there are certain variables which occur infrequently. This may necessitate delay in setting the standards until such time as these variables occur and can be studied. In a case of this kind there are two methods of procedure:

1. To set the standards for the variables which have already been studied, and later make a study of the other variables when they appear.
2. To hold in abeyance the standard on the operation until the other variables can be taken into account.

On account of the delays resulting from the infrequent occurrence of certain variables it is always most economical to take simultaneous studies on several operations. This prevents loss of time in waiting for a special kind of stock or material which it is expected will cover all conditions of the operation.

In the clothing industry, for instance, there is considerable variation due to the fact that the cloth used for summer goods is of a different character from the cloth used for winter goods. The two classes of goods naturally are not manufactured at the same time. If the winter goods are studied first, it may require, on the operation of cutting the parts of the garment from the bolt of cloth, from three to four months of the time of one analyst and one clerk to determine the standards. On the summer goods, which will be made six months later, standards can probably be determined in about a month, because it is possible to make use of much of the data already obtained on the winter goods.

Relative Time for Four Phases

In predetermining the amount of time it will require to standardize an operation the analyst takes into account con-

sciously or unconsciously the relative amount of time required on each of the four phases noted in Chapter III.

On most operations the third phase—analyzing the studies and setting the standards—takes the longest time. That phase should, therefore, be used as a basis for comparison. In general, the relation existing between the various phases of time study and job analysis is:

Phase I. (Preliminary.) This phase takes from 1/10 to 1/20 as long as phase III.

Phase II. (Taking.) This phase takes from 1/2 to 1/3 as long as phase III.

Phase III. (Analyzing.) Basis for Comparison.

Phase IV. (Applying.) This phase takes from 1/2 to 1/3 as long as phase III.

1. *Preliminary Work.* The amount of time required in the preliminary work differs greatly according as: (1) The operation to be studied is the first one in a particular plant, or the first one in the department where the nature of the work is different from that in other departments where studies have already been taken; (2) the operation to be studied follows or precedes some other operation already studied.

In the first case the preliminary work requires a study not only of the operation to be studied but a study—less searching in character—of the operations immediately following and preceding the one in question. Although in many cases this precaution may be unnecessary, it forestalls realizing at a later date that certain changes in the operation might have been made at the beginning instead of taking studies on a method found to be uneconomical. The *preliminary work* in this case will take *from one-half to one-quarter* of the time of phase III.

The preliminary work after the first operation has been studied requires ordinarily not more than an hour's time. In

some cases where the operation is closely related to some other operation already studied, this preliminary work can be dispensed with entirely.

2. *Taking the Times.* The phase of "taking the times" is something more than the layman's understanding of simply going out once or twice into the factory and recording the elements of an operation and the corresponding time of each element. The actual recording of readings on the time-study sheet is generally not more than 1/10 of the total time chargeable to this second phase. Practically every factory, even the one manufacturing a single product, has different grades, sizes or classes of stock it manufactures, or some other difference in the product, which means that studies have to be taken under each condition. At first the studies can be made on any kind of stock on which the employee happens to be working, but later the observer may have to wait until the stock not yet considered is in process. He will also have to make many trips to the factory, and on each trip time will be consumed in starting the study or waiting until the workman begins the particular grade to be studied. One way in which an experienced analyst saves time in this phase, is by not waiting for the employee to finish the job he had started before the analyst arrived but by commencing at once to take the time of the elements the employee is working on. The executive should bear in mind that the total amount of time as actually shown on the sheets does *not* represent the total time required to obtain the studies; in fact, the total time includes time to arrange conditions, talking to workman, etc., which amounts to at least ten times the amount of time recorded.

Much of the routine work of taking studies, however, can be handled by an assistant whose time is less valuable than the analyst's. In comparing the time taken to get results with the results obtained, this fact also should be kept in mind.

It has already been pointed out that there is not a definite limit to the number of studies which may be made on an operation. One operation may require only a dozen studies, while another may require a hundred. The character of the work and the variables determine the required number. In the interests of economy it is naturally desirable to cut down the number as far as possible, which may often be done by urging that distracting conditions be corrected or by not attempting to make studies of conditions which very rarely occur.

3. *Analyzing the Studies and Setting the Standards.* The third phase of job standardization may be compared to the process in the human body of digesting and assimilating food after it has been cut up into small enough pieces by mastication. While, however, the human body functions in a miraculous way in digesting and assimilating the food we eat without any conscious or physical exertion on our part, the digesting of studies cannot be accomplished in this way. To perform this most important work requires training, patience and concentration.

The reason for the usual lack of appreciation of the work involved in this phase of job standardization arises from the commonness of so-called "rate-setting"—i.e., determining piece rates by guess or by testing out a few jobs or by taking the cost figures of past performance—where the executive often turns over the data to some minor clerk for an answer. Why, then, he feels, cannot the job of analyzing the studies and setting the standards be assigned to almost any clerk and conclusions drawn therefrom in a few days?

The time studies which have been taken are full of mute evidence. It is the job of the analyst to take each element and study in relation to the element preceding and the element following, as well as in its relation to the operation as a whole. This may be best accomplished by some kind of tabulation or by entering the time of each element on co-ordinate or cross-

section paper so as to show graphically its relation to every other point. The plotting of points one by one will, in many cases, change what look like many unrelated points into a well defined line showing definite relations existing between them. In cases where the proper relation cannot be determined or where it is questionable, the analyst is obliged to take studies which will either confirm his tentative conclusion or make possible the determining of a correct conclusion.

It is to the interest of both the manufacturer and the employees to arrive at conclusions or results as soon as possible in order to get the benefits therefrom, but on the other hand the greatest care should be taken to guard against drawing conclusions from too few studies. The analyst is in the position of a judge in a court of law who must be able to have the evidence brought before him, weigh it pro and con, and in spite of pressure from one side or both reserve decision until definite proof is obtained. At the same time he must systematically analyze and compare that coming in with that already in. Finally comes a time after the evidence has been checked and rechecked when the analyst, like the judge, is satisfied beyond a doubt that his conclusions are correct. Then and not until then does he announce his decision.

The verdict in a law case is worked up with all necessary amplifications and qualifications so that nothing may be left to the imagination. Finally it is typed on special legal size sheets of paper, properly bound and certified. In a somewhat analogous manner the analyst puts down his conclusions in clear and clean-cut instructions covering exact methods of operating, effect of the variables involved, tools and equipment to be used under each condition, and so on, so that these instructions can be easily made use of and will not be misinterpreted. They are then appropriately typed, filed and indexed.

In the operation of placing a number of layers of cloth one on top of another as in the case of manufacturing clothing in

large quantities, it did not require a great deal of time to take the studies; but it was found in tabulating the results that the character of the cloth was difficult to classify. Some materials pull readily without distorting the cloth as it is pulled and evened off on the table, other materials have a fuzzy surface and stick to the cloth already on the table. Some kinds of cloth need to have the wrinkles straightened out carefully while the cloth is being laid, whereas other kinds give little trouble of this sort.

4. *Applying the Standards.* The fourth phase of job standardization, namely, applying the standards, consists of instructing the employees and keeping track of their progress and the results they accomplish until they are producing the work in accordance with the standards that have been set. If the operation is one in which only one or two employees are working and they are both first-class men the analyst will not have to spend, in all, more than a day's time on the matter. If, however, the operation is one in which the method of doing the work has been changed considerably, it may require all the analyst's time as well as that of an assistant and an instructor, for a period of a week or two, to get even one or two of the employees to produce the work in the time set. Then, another employee or two may be started who may require a somewhat similar period of instruction; but as one workman after another is taken on, the amount of time required of the analyst and instructor will become less for each man.

In applying the standards the person assigned to this work must be able to hold the good-will of the workmen in order to get them to work under the new standards. The analyst could not possibly learn to do expertly every operation he studies and standardizes so that a second person, namely, a practical workman, whether he is a foreman, inspector, or a man at the machine, must help in instructing the new men starting on the operation.

The employee upon whom the original studies were taken is, of course, familiar with what the analyst is doing and through this intimate relation sees the necessity for the changes. In fact, where the effected changes are the combined efforts of the men and the analyst, often the men actually work out the details themselves. In such a case the amount of time required in "applying the standards" is not so important.

Results of Curtailing Required Time

A well-known engineer of large experience in installing systems made the boast at one of the plants in which he was assisting that he could determine the standard for any one operation in a single day. He demonstrated his ability to do this by setting up a standard on an operation which was quite simple. After several weeks' endeavor on the part of the company to get their employees to come up to the standard he set it was found necessary to have the operation restudied and new standards set.

In this case the engineer did not realize his lack of experience with job standardization, nor did he realize the difficulty of the work; consequently, he was unable to establish standards that could be consistently lived up to.

The operation was restudied by an analyst who took into consideration all the variables. After several days of his full time, and about half a week's time of an assistant, new standards were set. These were put into effect by starting one employee at a time until all of the employees were convinced of the correctness of the standards. The effect upon the workmen of having to change the standard times, in fact, the effect upon the whole factory, was detrimental to the idea that standards could be determined accurately. It took months of earnest work on the part of the officials of the company as well as of the analyst who did the work fully to convince the employees that the new standards were correct.

It is well to remember that the output of an operation, the cost of that output, together with the compensation of the employees, will be based upon the results of the analyst's conclusions. Both the employer and the employees are affected by the analyst's decisions. In justice to both it is advisable to conduct an analysis so carefully, so thoroughly, and with such exactness that the conclusions may serve as a genuinely scientific basis for the standard output.

CHAPTER X

MAKING THE PRELIMINARY STUDY

Purpose of Preliminary Study

Before starting to make time studies the analyst will need to make a preliminary study for the following purposes:

1. To understand the essentials of the operation.
2. To find out present methods of operating.
3. To set standards for machines.
4. To find out what has been accomplished under these methods in order to compare records before and after the operation has been analyzed.

Essentials in the Operation

In order to grasp thoroughly an operation it is necessary to understand the correlation of the various factors of production involved in it. The relation of the factors to each other is discussed in a general way in Chapter XXI. It is stated there that one of the chief duties of the analyst is to decide which factors present the possibility of the greatest saving. The time for deciding this important matter is during the preliminary study. These factors are:

1. The characteristics of the workman.
2. Standards of quality to be maintained.
3. The material worked upon.
4. Machines and equipment.

Studying the Workman

The characteristics of the operation are tempered by the characteristics of the employees performing it. Therefore one

of the first things to do is to study the workman. To facilitate this study the names and numbers of all employees should be listed.

The Skilled Employee

It is especially important to note the skill of the different employees. When mention is made of a skilled employee, it is not an exceptional case that is referred to. "The skilled employee" may be defined as one fitted to his work, who is experienced and conscientious as well as reasonably deft. Too often even the foreman picks out an employee as skilled because he apparently works fast and is always doing something. These indications are no gage, as was illustrated conclusively on a brick-laying job. The foreman picked out one of his men as the best man he had. To watch this man laying bricks, probably anyone would have come to practically the same conclusion, for he moved at a rate 25 per cent faster than the other bricklayers and was always in action. A detailed analysis of his work, however, as compared to that of some of the other bricklayers showed that he actually laid only about 75 per cent of what the average bricklayer did. This was due to the fact that although he worked very fast, he went through many unnecessary motions. He always tapped the brick three or four times after it was laid in the mortar, so that the mortar oozed out and had to be cut off at the joint each time. It would have been enough to tap it once or twice, and then there would have been no necessity for cutting off the mortar so often. Moreover he handled his trowel most gracefully, but his flourishes, far from assisting him in laying bricks in the wall, actually used up considerable energy in useless motions.

Maintaining Quality

The quality factor should be given immediate consideration and its importance determined before any attempt is made

toward increasing quantity. The relation of quality to quantity depends upon the operation. In the case of manufacturing ladies' high-grade, tailor-made garments which will sell for $150 a garment, the quality factor is obviously paramount; while in the case of unloading pig iron it is practically nil. During the preliminary study the analyst should ascertain the importance of the quality factor and from company officials the trade requirements in order to set a well-defined standard by which all the work is to be measured.

There are two classes of workers, quality workers and quantity workers. The latter often slip poor work through, while the former occasionally take pains out of all proportion to the need. The analyst should bear in mind, however, that low output does not necessarily or even usually mean high quality. Both quantity and quality may be improved by setting a definite standard and, when the operation warrants it, instituting some form of check or inspection of the work of all the employees.

Materials Worked upon

As with quality, the importance of the material depends upon the individual operation. Almost every employee handles material carelessly. It is hard for him to realize how rapidly a small daily waste mounts into hundreds of thousands of dollars. Where the waste is great and the material expensive, a special study is advisable. This study should include analysis of all the sources of waste, the loss from each source and the means by which it could be corrected, and education of the employees in the consequences of throwing away material. In addition it is sometimes advisable to introduce special bonus payments for saving material.

Studying Equipment

The condition of the machines and equipment used in an operation should be carefully considered, especially in com-

mencing an analysis. Considerable time may be wasted in taking elaborate detail studies on machines and equipment which are in need of repair. In one textile mill it was found in the preliminary investigation that out of some fifty machines working on an operation not one was in proper running shape. On practically every machine all the belts were loose and in some instances the nuts were gone entirely so that the bolts had to be wired on to keep them from falling out. The result was that when any new part was put in, it was not very long before it either broke or became much worn. Such a state of affairs is almost unbelievable; yet it is not the only example of such a condition found in factories.

A preliminary study of an operation probably will reveal certain possibilities in regard to changes which may be made in the design or the method of operation of the machinery and equipment. This, however, may merely mean that the analyst makes a note of certain points, improvement in which might increase production. It does not mean that his suggestions are necessarily to be instituted or even to be tried out at the time. Each suggestion, however, should be carefully noted and entered on a separate suggestion sheet to be filed in a "suggestion book." Every time anything bearing on the suggestion is learned, it should be entered on the suggestion sheet. If this is not done and the sheets are not frequently referred to, there is danger that the suggestion book will become a graveyard of ideas.

Methods of Operating Equipment

The second purpose of the preliminary study is to gain an understanding of present methods of operating. This is done with reference to possible later improvements in mechanical methods, tentative layout of operations, and "group work."

1. *Mechanical Methods.* A study of the methods and routine already in use will probably disclose reasons why some of

the changes noted in the study of the operation would be unwarranted. The test should always be whether the saving would be in proportion to the expense involved. In some cases it may be found that a suggestion which might prove practicable later on would require more experience, more floor space, or more time than is available at the moment. Any mechanical improvement, even though it may seem exceedingly simple to make, means at best a certain amount of delay in getting parts made and a certain amount of experimentation before the innovation works practically all of which takes considerable time, to say nothing of money. Hence standards should sometimes be set on an operation at once, without waiting months before the change can be completed, so as to get immediate results in the way of increased production. Such immediate setting of standards, however, is only possible when the change does not materially affect the standard being set, or when the change is so fundamental that it cannot be brought about for some years and will then revolutionize the operation. It is not practicable to keep changing the standards because of repeated changes in method and equipment. Nevertheless, the analyst should bear in mind that it is much wiser to utilize to its full extent the existing machinery and equipment, thereby making money which can be expended for the development of refinements, than it is to try to reach absolute perfection at once.

An example of large saving at small expense is afforded by the wheeled truck, shown in Figure 21. A truck like this may be used both as a workplace and a truck, saving the loading and unloading of stock. In a manufacturing plant where a great deal of the work is seasonal the same idea is utilized in a slightly different fashion. Many of the workplaces are on wheels, so that they can be used singly during the season when small advertising booklets are being made, and in combination when large billboard posters are going through the plant.

To make expensive recommendations is a common error. The novice is bursting with a commendable enthusiasm for his work. He is in a hurry to reform the entire plant. Unfortunately, however, he brings to his task a good supply of

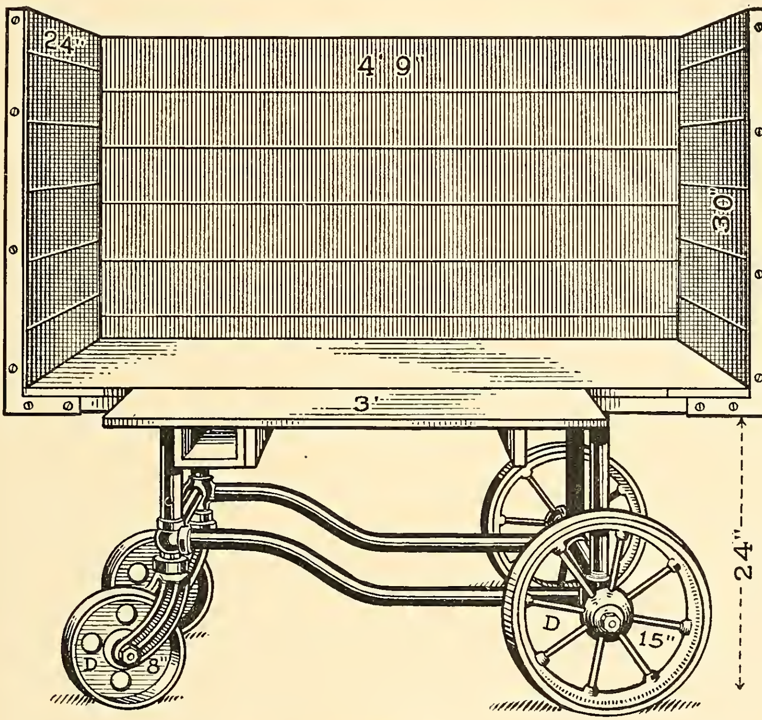


Figure 21. Combination Wheeled Truck and Workplace

ignorance as well as of enthusiasm, and unless he has considerable mechanical sense and considerably more common sense, he will make suggestions for improvements in machinery or methods that may save a little of the employee's time but that will not actually pay for themselves when all the factors are taken into consideration.

The analyst who sees his task in its larger aspects must at the same time try to get the point of view of the man who is employing him. The manufacturer is aware that improvements can be made in his plant and is willing to pay to have these made, but he wants them attended to as quickly and cheaply as possible and is anxious to have the changes pay for themselves as the work progresses.

2. *Layout of Operation.* What has just been said applies particularly to mechanical improvements. There often are, however, certain improvements in routine which may be made at practically no expense. For example, it is evident that each operation is related to the operation preceding it and also has a bearing on the operations that follow. Consequently a general survey of the department should be made with this fact in mind. A little observation may show that a change in the division of work will reduce the total time of completing the process—which means reduced costs. It is often practicable, for example, to reduce the number of times the stock is handled. In a certain textile plant the cloth after inspection was placed on tables, where each bolt was tied, or "tacked," as soon as it was placed there. When the table was full, the inspectors cleared it off by loading the bolts on trucks. By placing the material on trucks in the first instance instead of on the tables, the extra handling was eliminated and the number of girls engaged in "tacking" was reduced, because it was found to be easier to "tack" a number of bolts at once than one at a time.

3. *Group Work.* An operation performed by several employees working together as a team is called "group work," and during the preliminary study of a plant the analyst should consider the method there used of dividing the labor in this manner.

There are two classes of group operations: one done by a head and a number of assistants, and the other by a number of persons of about equal caliber working together.

In the first class, the main part of the operation is done by one employee who is in charge of the work but who is assisted by other employees. This is true of the operation of laying cloth, shown in Figure 22, where the leader should have a certain knowledge of the tailoring trade and the peculiarities of cloth so that he may handle each kind properly. Provided he has such knowledge he may make large savings by shifting the pattern or cloth so as to throw any imperfection into a collar or pocket, where if the part had to be replaced it would take the minimum of cloth to do it. One employee cannot do the work alone because the extreme width of the cloth makes it necessary to have an assistant to work on the opposite side of the table. The assistant, of course, has to learn how to handle the cloth, but he does not need a great deal of detail knowledge, and should, therefore, not be paid at so high a rate as the experienced employee who is responsible for the quality.

In the second class, several employees work together, each one doing his part in proper sequence. A simple illustration is that of three men driving a large stake into the ground with sledge hammers. Each man takes his turn in swinging the sledge. Each must perform his work in proper sequence. If one of the men is slower than the other two it will be necessary for the other two to slow down the swing of the sledge in order that all three of them may work in unison. This is an example of the way in which the slowest employee sets the pace for the group.

Standardizing Machines

The third purpose in making a preliminary study is to set standards for machines. In many factories uniform standards have not been set, even for machines of the same type doing the same sort of work. As the business grows, new machines are constantly being built which have minor improvements of one sort or other. Unless the mechanical superintendent, how-

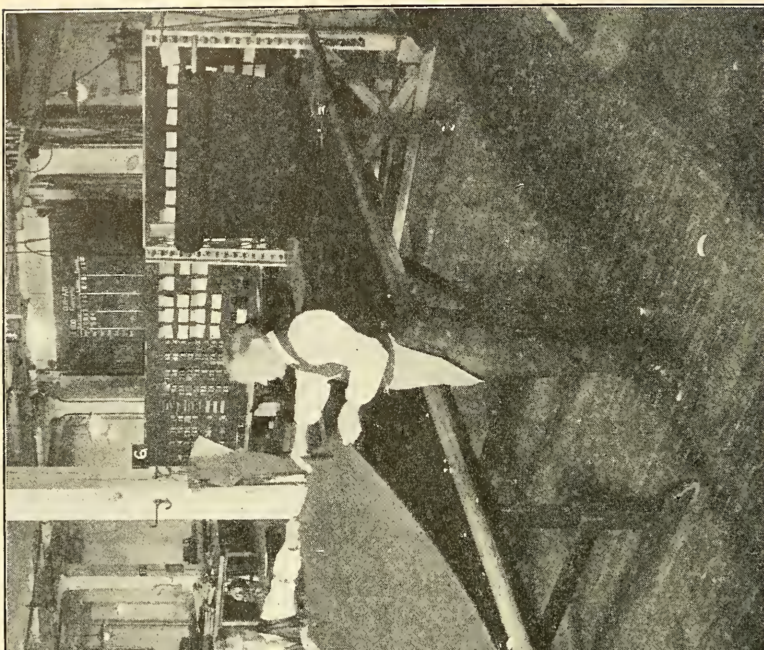


Figure 22. Operation of Laying Cloth

ever, has a vision of the work as a whole, the new machines built may not include all the good points of the old, nor the old be changed so as to have the good points of the new. In a certain textile factory someone once had an idea that the winding machines could be run faster without injury to the material, and accordingly had the pulleys on one of the machines changed. The experiment, however, was never followed. The other ten machines of the same type were kept at the old speed, although everyone in the department knew that the machine on which the pulleys had been changed was doing more work and just as well as the slower machines.

During the preliminary study the analyst should start a campaign for setting standards for the machines, and should see to bringing them to these standards. The machines should be calibrated and those doing the same work should run at one speed—the speed which is most satisfactory for the work. All improvements worth-while on any one of the machines should be introduced for all the machines of that type, changing the necessary parts, making all machines of this same type alike, and putting all of them in line with what are determined to be the best standards.

Improvements for the purpose of *standardizing machines* should not be confused with suggested improvements intended to *increase production.* These suggestions were discussed earlier in the chapter when the effect of the machine factor on the operation was considered. It was pointed out there that these suggestions were not to be instituted or even tried out during the preliminary study, but were to be noted in the suggestion book.

Production and Earnings

After job standardization is well under way, all persons interested—and these include employer and employees as well as the analyst and his assistants—will wish to know what is be-

ing accomplished. Moveover, certain data are needed in the advanced stages of job standardization which, if not on hand at the time, will seriously hold back the work. The fourth purpose of making the preliminary study therefore is to size up the situation and to start the process of gathering necessary information. In all cases information is necessary on these two points—present production and present earnings of employees.

One of the points of which the management will wish to be and should be informed is the increase in production brought about through job standardization. It is important that the head of the department be able to furnish this information, since it may have considerable effect on the officials in determining the company's future policy.

In order to find what increases in production are made possible through the analysis, it is necessary to compare the amount produced after the analysis with that before it was begun. Although the employees have a general idea, and in some few cases a correct idea, of the amount they turn out from day to day, it is not advisable to trust to figures obtained from the employees. Definite facts are essential in getting the co-operation of the executives. The figures as shown by the company's records whenever they are available are to be used for all comparison between previous production and production after job standardization has been introduced.

If these records are not available, then steps must be taken immediately to have some actual records kept of production, classified according to employees and orders and differentiating between different classes of goods manufactured. The analyst may specify the records and data he needs, but the data should, if possible, be accumulated through the regular channels and independently of the analyst—especially if he is a man from an outside company of consulting engineers.

An official in a company realizes only too well that production varies from time to time and that records should be taken

over a long period in order to get a fair average. He is, therefore, prone to question any comparisons which are not based on records covering a long enough period to give fair averages.

Drawbacks of Special Records

In a certain mill about a year ago the operation of sorting paper was studied. The operation consisted of inspecting paper for off-shades and imperfect sheets, but no adequate records had been kept of the production so that there was nothing on hand to show the average output per employee. Records were at once begun by the analyst before he commenced detail studies.

After the standards had been determined he estimated from these records that if the employees worked according to the standards set, the production would be increased 100 per cent. The net savings would then amount to between $6,000 and $7,000 a year, even if the volume of business remained the same. The possible savings, if the increase in business was in proportion to the increase in efficiency, would be $20,000 a year.

As the general manager was in government service, the report was submitted to his assistant as a basis for extending the system into another department. Since the figures had not been compiled by his own cost department and the method of analyzing the situation was different from any previously used in the plant, he seemed doubtful and was unwilling to have the analysis work extended to another department.

When the general manager returned, he ordered the work started in the second department, basing action largely on his confidence in the analyst. In this department, however, the cost department had adequate records both before and after the installation, and the analyst was able to show from these records an increase of 100 to 150 per cent. Thereupon the assistant to the general manager at once accepted the figures,

with the statement that with such results the work should be extended immediately to every department in the mill.

In the course of the preliminary study, the earnings of the employees should also be tabulated, with remarks as to variations in the pay due to years of service, age, previous experience, and so forth. This data should be kept in the analyst's special file for ready reference. Great care should be taken not to let this information become public or even allow it to be looked over by any unauthorized person. It should be used later in deciding adjustments to be made when the new routine is established.

Sample Instructions for Preliminary Study

Perhaps the best way of summarizing what should be accomplished by means of the preliminary study is to print as a sample the instruction card made out by an engineer some months ago for an assistant about to undertake the preliminary study in one of the departments of a paper-mill.[1]

These instructions were given on cards as the headings indicate. The points are listed numerically. The work, however, did not have to be done in numerical sequence. The first instruction card is a survey of existing conditions at the commencement of the study, involving the ascertainment of what had been accomplished under these conditions and the gathering of all information necessary to an understanding of the operation. The second card describes the general line of attack and the setting of standards for machines and methods. The assistant should do first that which seems easiest. A clerk, for example, would probably do the first point first, viz., listing employees by name and number, whereas an outsider might wait before getting this data until the names meant something to him.

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[1] Instructions made out by H. M. Davis of the Thompson and Lichtner Company.

Instruction Card

No. 1

Subject: Gummed Slitting Job Analysis

1. Labor Statistics

 Get names and weekly earnings of employees, kind of operations they can do (in the order of their expertness), length of service and remarks on their capabilities, etc.

 Get a report on labor turnover.

 Report also on number and causes of accidents. (This may be helpful in deciding what changes ought to be made and what changes cannot be made.)

2. Standards of Quality

 Report on nature of work performed.

 Extent of inspection done.

 Quality of incoming paper.

 Defective work that might be caused by operators or machines.

 Required quality for outgoing work.

 Volume and nature of seconds and how picked out.

 Waste; amount, reason, and method of handling. Is the machine ever stopped to take out waste?

3. Material Worked upon

 Product handled. (Get samples.)

4. Machines and Equipment

 Report the equipment now on hand.

  Machines.

  Type.

  Speeds, constant or variable, and how much? Have machines ever been changed and if not, the reason why? Talk with foreman and compare different machines.

 Method of operating.

  List the operations that characterize each machine.

  Troubles peculiar to each machine, or combination of machines, and product.

  Small tools.

  Trucks.

  Benches.

  Labels, roll tags and other identification marks.

5. Present Methods of Operating
   - Work by slitters.
     - List detail operations on each machine.
     - Note difference due to operator and those due to machine.
     - Talk to employees in order to get acquainted and to find out troubles from employees' point of view.
     - Auxiliary members of department.
     - Note in some detail what is done.
   - Mechanical repairs on belts.
     - How is this work handled?
   - Make a floor plan of the department (1/8 inch equals 1 foot), showing all machines, benches, storage spaces, unslit rolls, slit but not bundled, bundled but not packed, packed, waste.
6. Present Methods of Planning and Controlling
   - Division into customers' work orders and mill orders.
   - How is work moved up to the machine?
   - How is work accounted for at the machine?
   - How is work moved away from the machine and accounted for?
   - How is work placed in storehouse as semi-manufactured, finished stock, seconds, make and hold for customers, etc.?
   - How are cases ordered and received? How are dimensions fixed?
   - How is waste accounted for?
     - Talk with head of Planning Department, foreman, clerks.
     - Get samples of all tickets and forms and fill in enough data to show the use.
7. Present Records
   - Plot curve for each machine showing output for last six months.
     - Report similar data for bundlers and packers.
   - Departmental down time.
     - Examine reason for down time shown on four-weekly reports and report the amount for each machine for six months' time for various reasons reported.
   - Volume of business handled.
     - Can the company sell enough business to utilize any increase in capacity we give them?
     - What has been the volume of business in the past?
     - Report.
       - Volumes of various grades handled, troubles peculiar to each. What lines should we study first?

Output of the gummers, total for the department and down time by per cent.

8. Suggestions from Members of Department

Encourage suggestions by superintendent, foreman, operators, and get all ideas possible.

Report in typewriting, with samples, tables of data, floor plans, forms, etc. The work should be done by June 1, 1920.

With these reports as a basis, we should be able to decide the order for studying operations (slitting, bundling, packing, layout) of slitting machine and products. If we get an immediate increase on the slitters, will the gummers take it up promptly, and can the bundlers and packers get it out of the way fast enough to avoid a jam?

Instruction Card

No. 2

Subject: Gummed Slitting Job Analysis

General Line of Attack

A preliminary survey of the gummed slitting work indicates that the problem is chiefly one of mechanical changes on the machines and in the layout of the department, including methods and equipment used in getting the rolls onto the machine and in getting the coils from the machines into the packing cases. With so many variables in type of machine and also in product, the work will have to be carefully handled to avoid running into two years time, studying and revising mechanical changes and in getting them made.

The job ought to be only a question of months.

In general, we should handle all machines as a unit until they are all in shape to start final time studies for bonus. Make one job of revising the method of getting the feed rolls onto all machines, and while waiting for the equipment to be installed work out improved methods of changing finished coils for all machines, and while this work is being done by the mechanical department take up another job.

Preliminary Time Studies

Make a short-time study, ¾ hour to 1 hour on each machine, to get a close line on the down time and the different methods in

use. Do the same thing for the workers bundling, packing, or otherwise handling coils. A shorter study (½ hour) should be enough here.

List the operations and symbols you intend to time and refer to the analyst before starting. Work up these studies.

Changing Feed Rolls

Find a method of changing feed rolls that cuts the machine down time for the operation to a minimum.

Draw on plotting paper a cross-section of the back of each machine (where there is any difference) showing the floor level, bearings for feed rolls, shafts, parts connected to the bearings (uprights, etc.). Show also a back view with any necessary detail that affects the way rolls should be put in, such as friction, slitting knives, etc.

The general aim should be to have a feed roll ready ahead of the machine with an extra shaft in place ready to drop into the machine in the right position to give the necessary trim on each side of the roll.

The sketches you can make on the job direct from measurements should be plenty good enough for the purpose.

Miscellaneous

Arrange with the gumming planning department to let you know when knives are to be changed and get a study on the methods and time of doing the work. If we need an extra shaft and extra knives for this work we must get them ordered.

Arrange to have the department clerks make an inventory of the mechanical equipment in the department and report if it is up to date, properly marked, and stored. Decide if we should not design racks and bins properly labeled, with benches all arranged as one compact workplace where all machines can be taken care of.

CHAPTER XI

TAKING THE TIMES

Systematized Analysis

Since taking detail time studies of an operation is inevitably a long process, involving much careful work, the analyst should make every moment pay and make every study of value. The detailed work is what brings lasting results, but it is possible to save time by substituting for many hasty, poorly considered studies a relatively small number taken according to the best method. A thorough preliminary survey, as described in the previous chapter, is one way to shorten the stage of taking the times. This stage can also be shortened by using the technique of job standardization.

Employee and Machine

As always, the human element is the first to consider. This is necessary in every operation, including even one which is practically automatic, for whatever the machine, some human being has to spend a certain amount of time tending it. The range of human activity varies greatly with various operations, but in every case the human factor must have first consideration.

The choice of the employees to be studied will have an effect on the value of the studies. From one point of view, it is possible to look on the study as the product of the joint efforts of the observer and the worker. It is important, therefore, that the right employee be selected, and just as important that he understand the purpose of the studies. There is only one standard for a machine, and it is comparatively easy to

decide whether it is up to that standard or not; but there are all kinds of standards to which a man may measure up. The analyst must decide which of these standards is necessary to the operation in question—whether, for instance, it is a standard of quality or quantity—and to what extent the employees reach it.

It is advisable first to talk over the employees with the foreman of the department. He usually has a clear idea of their capabilities. Some of them, at least, he has instructed in the operation. He knows who have acquired their experience at other plants, and who have simply picked up the method of doing the work as best they could. From his knowledge of what the various employees turn out from week to week and from watching them at work he will have formed his opinion as to their qualifications. A talk with him in regard to these points, as well as in regard to the temperament of the employees, their weaknesses, and their receptiveness to new ideas, will help the analyst to decide on the method of approaching the employee who is first to be studied.

Studying the Skilled Employee

Although due consideration must be given to the relative importance of quality and quantity on the operation, one thing may be said definitely—the studies should be made on an employee who is skilled. This is advisable for the following reasons:

1. His motions are more uniform.
2. He works more steadily.
3. He is apt to use the best methods and to adapt himself more easily to new ones.
4. The influence of the personal equation is less pronounced.
5. The results manifest his fluctuations and are more dependable.

The erratic work of the unskilled employee throws all manner of unnecessary variables into the detail unit times. It will be necessary to determine whether the variation in the time taken by an element is due simply to the fact that the employee is unskilled, or is due in part to the material he is working upon or the tools he is using. Under these conditions it will require more studies and a greater degree of skill on the part of the analyst to determine the correct times accurately.

In group work, since the speed is limited by the speed of its slowest members, the personnel of the group must be considered to see whether it is composed of skilled employees, and if not, whether such a group can be brought together.

Gaining Employees' Good-Will

In Chapter VIII the analyst was advised not to consider the employees or "operators" in his campaign for enlisting co-operation, but to direct his attention chiefly to gaining the good-will and assistance of the executives, the superintendent, and the foreman. When, however, his work touches the employees immediately, he should endeavor to win their personal co-operation. This should be done by talking to them and explaining as far as practicable what he is trying to do. During this stage of taking the times the analyst will, before and after the studies, make the most of the opportunity of getting acquainted with the employees.

Operation and Element Defined

The term "operation" is used to describe any course or series of acts performed either by one workman or by a group of workmen as a unit, which either adds one step to the complete process or constitutes in itself a complete process; while the term "element" refers to any division or subdivision of an operation which corresponds to an individual motion, and which has definite points of starting and stopping. The

principle of time study and job analysis is the discovery of the time required not only by an operation as a whole but by each part of the operation. Accordingly, the first act of the analyst, upon commencing the time study, is to break the operation into its elements.

Analyzing the Operation

The advantage of analyzing an operation into elements is that each one of these can be considered separately, with a view to its effect upon the whole, the factors having an effect on it, and its possible improvement. Moreover the elements can be recombined to apply to different conditions, so that it is not necessary to be continually taking new studies whenever requirements are slightly modified.

An operation must be divided into elements which are small enough so that each one will not include too many motions. If it is not studied in enough detail, the unit times may show great variations which cannot be explained. When this occurs, it means taking more studies that have to be worked up, and in all probability more time will be lost than if the operation had been broken into smaller elements at the start. The disadvantage of breaking the operation into more elements than necessary is that it requires a great deal of skill to observe the times taken by a series of elements, each occupying, say, less than .02 minute, and that it requires much more study of these extremely small elements to determine the amount of time to be allowed for each. Although it is not absolutely necessary to separate several of these very small consecutive elements, as a general rule the results will be more accurate where this is done—it is better to break an operation up into too many elements rather than too few. Several elements can be readily combined, while an element which is made up of several consecutive movements cannot be further subdivided without taking more studies.

Sample Analysis

Take, for example, the operation of laying cloth. The men laying cloth walk the full length of a bench, pulling the cloth a distance of 8, 10, 12, or more feet, depending upon the length specified in their instructions. They can straighten and even the cloth on their return to the head of the table where the bolt is on the rack, so that any wrinkles or folds will be removed before they cut the cloth to the desired length. The elements which should be taken for this part of the operation are:

1. Pull cloth (specify length) feet.
2. Straighten first section.
3. Straighten and even (specify length) feet.
4. Walk (specify length) feet.
5. Obtain shears.
6. Cut.

If the elements "straighten and even" were combined with "walking" as it might be by some analyst, great fluctuations would appear which would be hard to account for. If "obtaining shears" and "cutting" were combined, it might be hard to set the standard time which either one would take, since delays —such as that of looking for the shears—might occur during either one of the elements. By keeping them distinct the analyst avoids confusion. In the element "straighten and even," moreover, the observer notes the number of straightenings which the employee actually makes, so as to determine for each kind of cloth the number required. Some cloths may require only two straightenings for a 12-foot length, while others may require two or three times as many straightenings. Again some cloths have a smooth finish and require but a short time to make each straightening while others have a rough surface and require much more time in which to make each straightening.

Symbolizing Operations

The use of symbols is general in scientific methods of management. It is desirable that standard symbols be adopted and used by everyone as standing for the same thing. A chart of symbols used to describe the various products of a bleachery is shown in Figure 23, showing the general principles of symbolization.

The observer may analyze the operation into its elements before starting the stop-watch, or, if the unit times are not short, during the taking of the readings. As each new element is performed, he should make a note on the sheet, stating the action it involves—as, in the operation of laying cloth, straighten and even, obtain shears, or cut. He will then give the element a letter or symbol so that when it occurs again there will be no further necessity of rewriting the entire phrase. Thus in laying cloth "e" might stand for "straighten and even" and "c" for "cut."

There are two methods employed for symbolizing the elements. One is to assign the first letter of the alphabet (a) to the first element, the second letter (b) to the second element, and so on. The other method carries out the mnemonic idea, selecting as the symbol the first letter of the main word or its main vowel, or even, when these letters have both been employed, the first letter of a word synonymous with the word in question. Thus (p) might be used for "pull cloth," (s) for "straighten first section," and (e) for "straighten and even." Although the first method of using the letters of the alphabet in regular rotation is satisfactory on operations where the elements are always performed in the same sequence, and on operations where so many studies are taken that there is no trouble in remembering the symbol chosen, it is generally better to employ mnemonic symbols. The main advantage is that the mind readily associates the words with the first letter or main word. Moreover, since the observer will often use

TURKISH TOWELS			Flannels	Crashes		Huck Towels		FINE GOODS										
Wash Cloths	Towels	Terry	Flannels	Twill	Plain	Towels	Towelling	Satteen	Repps	Piques	Nainsook	Muslin	Longcloth	Corset Goods	Osnaburg	Dress Ducks	Cambric	Butcher Linen
TW	TT	TR	LF	JT	JP	GT	GL	ES	ER	EP	EN	EM	EL	EK	EG	ED	EC	EB
				KT	KP	HT	HL	FS	FR	FP	FN	FM	FL	FK	FG	FD	FC	FB

GENERAL CLASSIFICATION: NAME OF GOODS — FIRST AND SECOND LETTERS OF SYMBOL (upper line BACKFILLED, lower line PURE); DETAILED CLASSIFICATION

THIRD LETTER OF SYMBOL — PROCESS AND FINISH — TO BE USED WITH ALL EXCEPT SHOE GOODS

Letter	Detailed Classification	Marked for
A	Singed, Bleached, Starched and Calendered	ES, EK, ED, EC, EB
B	Singed, Bleached, Starched, Calendered and Framed	ER, EP, EN, EK, EC, EB
C	Singed, Bleached, Starched, Framed and Calendered	ES, ER, EP, EN, EK, ED, EC, EB
D	Bleached, Starched and Calendered	JT, JP, EM, EL
E	Bleached, Starched, Calendered and Framed	EM, EG
F	Bleached, Starched, Framed and Calendered	JP, EM, EL
G		
H	Bleached, Starched and Framed	JP, EG
J	Singed, Bleached, Starched and Framed	ES, ER, EP, EK
K		
L	Bleached, Run Through Flannel Combination and Inspected	LF
M	Bleached, Starched, Calendered and Mangled and Beetled	GT, GL
N		
P		
R		
S		
T	Bleached, Run Through Bluing Mangle & to Turkish Drying Room	TW, TT, TR
U		
V		
W		
X		
Y		
Z		

FOURTH LETTER OF SYMBOL "PUT-UP"

Letter	Detailed Classification	Used with	Marked for
A	12" Double Back	TO BE USED WITH FINE GOODS	ES, ER, EP, EN, EM, EK, EG, ED, EC, EB
B	12" Manufacturers' Single Back		ES, ER, EN, EM, EK, EG, ED, EC, EB
C	9" Fold		ES, ER, EP, EN, EM, EG, ED, EC
D	6" Regular		EM, EC
E	6" English		EM, EC
F	Barnsley Fold		
G	Cuttle Fold		
H	Dress Fold		ED
J	Silk Fold (Same as Dress Fold)		ES, ER, EP, EN, EK
K	Longcloth Fold		EM, EL, EC
L	Doubled and Book		EN, EM
M	Doubled and Lapped on Wood or Cardboard		
N	Doubled and Rolled on Plate		EM, EC, EB
P	Single and Lapped on Blade (Wood or Cardboard)		
R	Crea No. 1 Fold		EM, EC
S	Crea No. 2 Fold (Skirt Fold)		EM, EC
T	Rolled on Spindle		EM, EC
U	Rolled on Tube and on 3-5 Wood Shells		EM, EC
V			
W			
X			
Y			
Z			
P	Huck Fold (Papered)	USED WITH HUCK GOODS	GL
R	Huck Fold		GL
C	Cut and Tied in Bundles of Five Dozen		GT
H	Cut, Hemmed and Tied in Bundles of One Dozen		GT
J	Cut, Hemmed, Tied and Papered (Two Dozen in a Package)		GT
S	Cut, Hemstiched and Tied in Bundles of One Dozen		GT
T	Cut, Hemstitched, Tied and Papered (Three Doz. in a Package)		GT
F	Barnsley Fold	USED WITH CRASHES	JT, JP
T	Rolled on Spindle		JT, JP
U	Rolled on Tube and on 3-5 Wood Shells	USED WITH FLANNELS	LF
R	Rolled on Spindle, Tied and Papered	TO BE USED WITH TURKISH GOODS — TERRY	TR
C	Cut and Tied in Bundles of One Dozen	TOWELS	TT
D	Cut, Tied and Papered (One Dozen in a Package)	TOWELS	TT
F	Cut, (Fringed) Tied in Bundles of One Dozen	TOWELS	TT
G	Cut, (Fringed), Tied and Papered (1 Doz. in a Package)	TOWELS	TT
H	Cut, Hemmed and Tied in Bundles of One Dozen	TOWELS	TT
J	Cut, Hemmed, Tied and Papered (One Dozen in a Package)	TOWELS	TT
S	Cut, Hemstiched and Tied in Bundles of One Dozen	TOWELS	TT
T	Cut, Hemstitched, Tied and Papered (1 Doz. in a Package)	TOWELS	TT
C	Cut and Tied in Bundles of Five Dozen	WASH CLOTHS	TW
D	Cut, Tied and Papered (Five Dozen in a Package)	WASH CLOTHS	TW
H	Cut, Hemmed and Tied in Bundles of Five Dozen	WASH CLOTHS	TW
J	Cut, Hemmed, Tied and Papered (Five Dozen in a Package)	WASH CLOTHS	TW

Figure 23. Chart of Symbols Used to Designate Various Products of a Bleachery

the same symbols for common elements irrespective of the operation in which they occur, as w for walk, or s for stopping machine, it facilitates a comparison between the times taken by the same element under different conditions.

Results of Imperfect Analysis

Analyzing an operation seems to the uninitiated to be very easy. This is true if the operation is broken up into its major elements only, but as a general rule it is necessary to break it up into smaller elements in order to study it in enough detail. In some cases, for example, the element of picking up the material should be separated from the element of placing it in position. The object of this is to determine the variation in time of each of these elements for varying conditions of work, weight of material, or whatever the variable happens to be.

The results of the failure to analyze the operation by recording all variables in sufficient detail were well illustrated in a case where a so-called experienced man made a detailed study of the operation of "stitching pads on calendars." The difference between a hasty, inaccurate study, in which all variables were not taken into account and a scientifically exact study is clearly brought out by citing this example in detail.

The job of wire-stitching date-pads on the backs of calendars is a relatively simple one. The analyst, Mr. X, took fourteen studies—one study each on half of the total number of machines in the room, except on No. 2 machine, on which he took five studies. Each study occupied from two to ten minutes.

From the results of the fourteen studies, taking in all less than two and a half hours, he drew up a curve, reproduced in Figure 24, which he maintained covered the standard for the job. Then he added an extra 35 per cent for delays. Just how or why he settled upon this figure of 35 per cent he did

not state; evidently he assumed the figure arbitrarily. He made the error, however, of failing to record all the variables

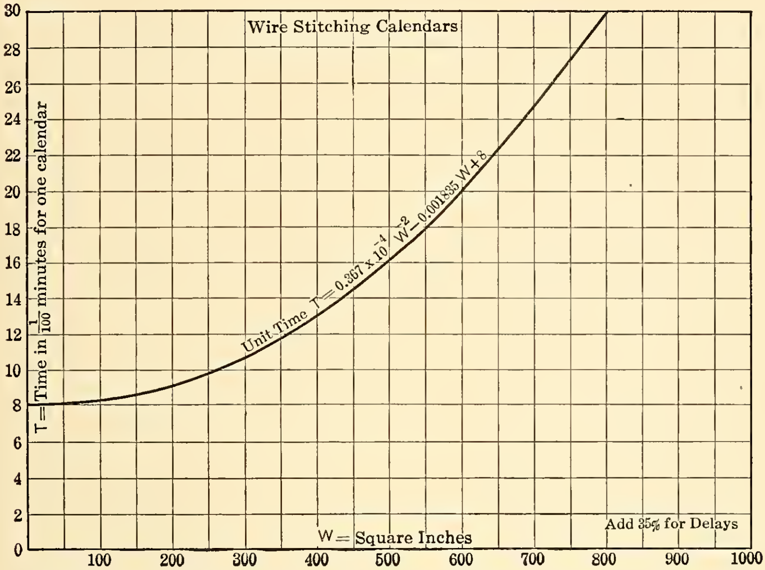

Figure 24. Incorrect Time Curve for Wire-Stitching Calendar Backs

affecting the task. It was later found from careful study that the time required for wire-stitching calendars was dependent upon five variables:

1. The stiffness of the calendar back. The calendars could be grouped into two classes; either stiff- or limber-back.
2. The size of the back. The size of the back was anywhere from 100 square inches to 600 square inches, with the ratio between the width and the length anywhere from 1 to 1, up to 1 to 2½. This ratio between width and length was a factor only when the area was over 440 square inches.

3. The size of the pad, which ranged anywhere from 10 square inches to 160 square inches.
4. The location of the pad. If the pad was located anywhere except at the very bottom of the calendar, a lifting gage on the stitcher had to be used.
5. The number of wire stitches, which varied from 2 to 15.

Of these five variables, Mr. X considered only one, the size of the calendar, and even in this one he failed to take into

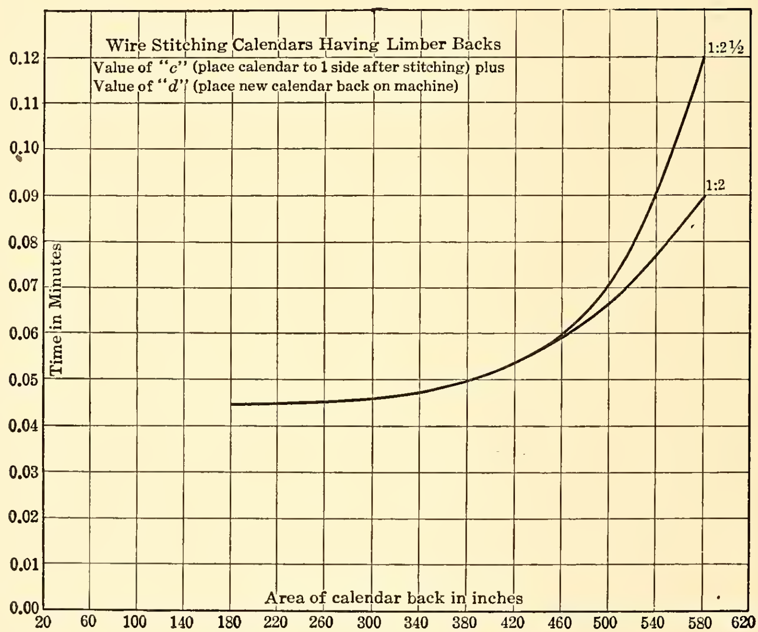

Figure 25. Correct Time Curve for Stitching Limber-Backed Calendars

consideration the ratio of the width to the length of the calendar. Of course the rates thus reached were not satisfactory, and the job had to be restudied. Figures 25, 26, and 27, show the correct time curves for wire-stitching calendar pads.

The following examples show the difference in time between results arrived at by correct methods and those incor-

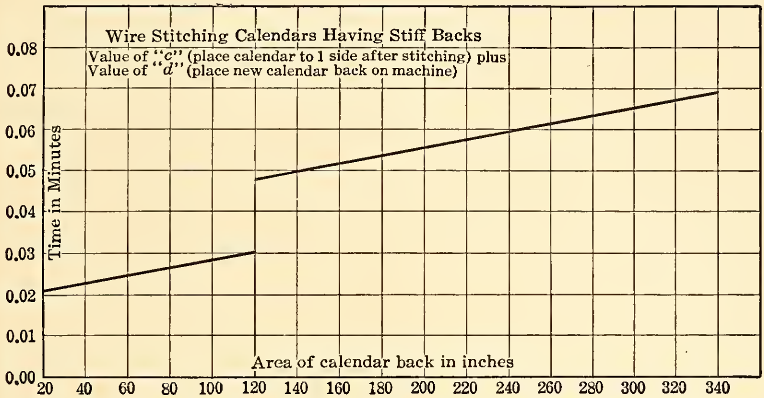

Figure 26. Correct Time Curve for Stitching Stiff-Backed Calendars

rectly reached. On an order for wire-stitching 4,000 flexible-backed calendars, 12 inches × 20 inches, having a pad 12

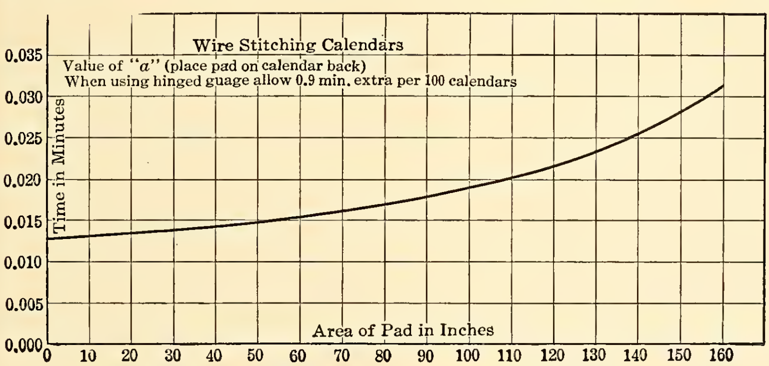

Figure 27. Correct Time Curve for Wire-Stitching Calendars

inches × 5 inches, to be placed at the bottom, each calendar requiring three wire-stitches, the correct time allowance for this stitching was 6 hours, 51 minutes, whereas X had allowed 8 hours, 4 minutes, or 21.6 per cent too much time.

For the stitching of 4,000 stiff-backed calendars of the same size and characteristics as in the first instance, the correct allowance was found to be 8 hours, 12 minutes, whereas X's allowance was 8 hours, 44 minutes, or 6.1 per cent too much time.

If the order consisted of stitching 4,000 flexible-backed calendars, having a pad, 15 inches × 5 inches, to be placed at the bottom, each calendar requiring 3 wire-stitches, the correct allowance was 11 hours, 11 minutes, whereas X had allowed 15 hours, 50 minutes, or 29.4 per cent more time than necessary.

Position of Observer with Relation to Employee

The position of the analyst while observing the operation and reading the stop-watch should be determined with care. In order to obtain a dependable study, the observer should take it from a position in which he can see exactly what the employee is doing, as well as what the machine is doing. The tendency of the beginner is to get directly in front of the employee, because he has to concentrate so hard on getting the correct time for each element that he fancies if he were anywhere except almost on top of the employee, he would not be able to see the exact moment at which each element is completed. By so doing, however, he distracts the employee, who is working under a strain, which does not subside quickly because he is always conscious of being watched. Sometimes the employee is further handicapped by the observer's taking a position which shuts off the light or by his being in the way of materials being moved by the employee.

The proper position, as a rule, is to stand at least 5 feet to the rear and to the right or left of the employee. This allows the observer to see everything that is going on, but does not confuse the employee, who will gradually become engrossed in his job and work naturally.

Figure 28 on page 167 shows the observer standing in the correct position to the rear of the employee. Figure 29 on page 169 shows incorrect position.

Instead of questioning the employee during the course of the study as to why he does or does not do a certain thing, the observer should wait until the study is completed. The employee will be able to give all the information just as well at the end of the study as during it, and the observer will have the advantage of a record that is not indefinite because of abnormal conditions which he himself caused.

Handling Stop-Watch

The method of handling the stop-watch has considerable bearing on the success of the analyst in getting accurate data in a short time. The readings of the stop-watch supply the time measure of the operation and the information on which final time standards are to be based. The method, therefore, should give the times of the elements separately so that they may be later considered as distinct, may provide a record of the exact times taken by them, and yet afford a record of the place of the elements in the operation as a whole.

The methods used are:

1. Continuous method.
2. Over-all method
3. Repetitive method
4. Accumulative method
5. Cycle method

1. *Continuous Method.* The continuous method gives the most satisfactory results in most cases and on most operations. According to this method, the elements are recorded in sequence without stopping the watch. The observer keeps the watch going continuously during the period of the study, making a mental note of the time as shown on the watch at the instant

each element is completed and then recording that time on the sheet opposite the appropriate symbol. He should do all this with sufficient speed and concentration to be free to note and write the time of the completion of the next element. As the reading of the watch is practically instantaneous there is no necessity for stopping the hand.

The stop-watch escapement allows the watch hand to make 3 forward moves each .01 minute. Although if the hand were stopped, it would be possible to read to .003 minute, a reading to .01 minute is accurate enough for the usual observation. A variation of .01 minute in an element taking as much as 1 minute is only 1 per cent—a negligible percentage of variation. Moreover it has been found that the law of averages applies on this work, and that an observer will in about 50 per cent of the cases read ahead to the next .01 minute and in the other 50 per cent will read back to the next .01 minute, which neutralizes the variation of readings and gives the correct total time for an operation.

The continuous method meets all of the requirements cited above, giving not only the exact time for each element as a distinct entity, but also the times of all the elements in the order of their performance. Further advantages of the continuous method are that it charges up every minute of the time for the duration of the study either to some necessary element, which may be called a "productive" element, or to an unnecessary one, which may be called a "non-productive" element; it also eliminates any danger of omitting delays.

2. *Over-All Method.* Many novices attempt to use in place of the continuous, what may be called the "over-all" method. They take the total time for a combination of several elements or even for an entire operation, starting the watch at the beginning of the group or operation, and making no record until it is finished. This method reduces to a minimum the figuring required but is of little value except for the purpose of check-

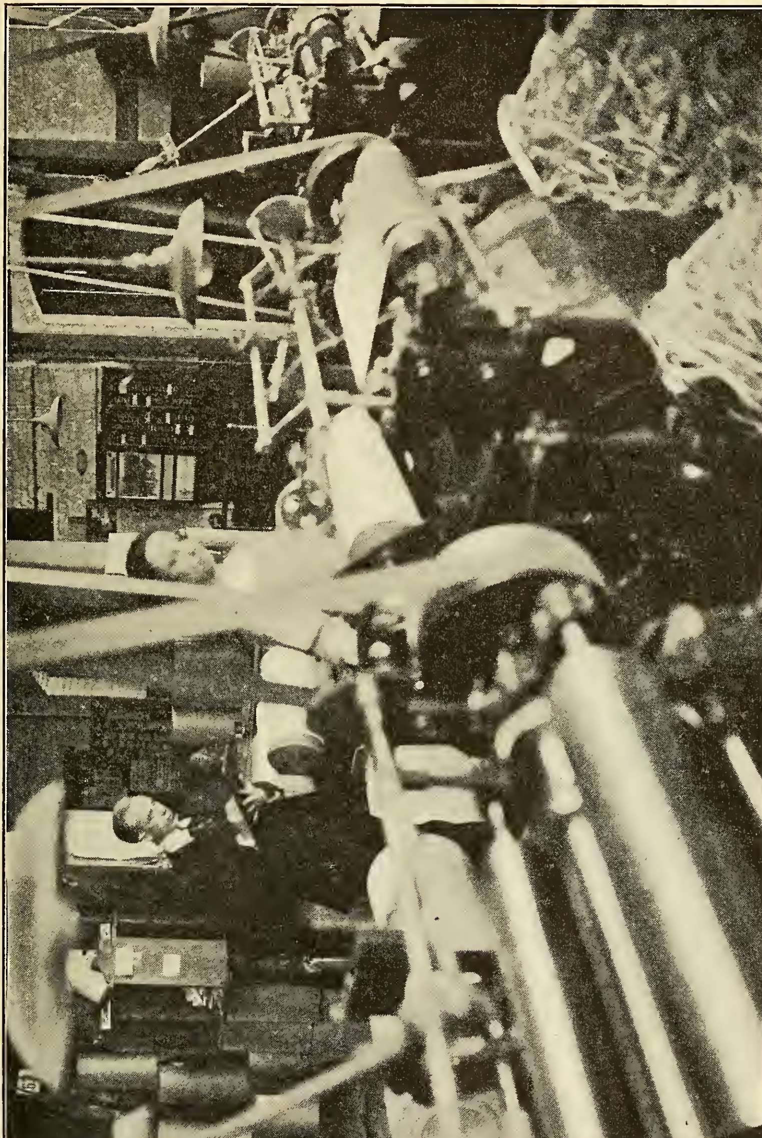

Figure 28. Observer in a Well-Chosen Position for Taking a Time Study

ing or supplementing conclusions drawn from detail or elementary time study. It should *never* be used, in place of detail time study, because it neither allows for improvements nor shows delays, and for that reason is not applicable to the setting of accurate standards. It is, indeed, no great improvement over the foreman's guess.

3. *Repetitive Method.* Another method of taking times used by novices is that known as the repetitive method. According to this, the observer starts the watch at the beginning of an element, stops the watch when the element is completed, and records the duration of the element. The watch is then thrown back to zero. When the element appears again in the cycle, the observer starts the watch which is at zero, stops it when the element is completed, and once more records the time taken. In this fashion he may record several elements in one study, provided they do not occur consecutively.

This method, like the over-all method, is easy for the observer and does not require much figuring. The conclusions drawn from it, however, are unsatisfactory, because one element should not be abstracted and timed apart by itself. The time taken to perform one element is more or less related to the time taken for the preceding element, since the employee usually swings from one motion to another without the slightest hitch or stop. The repetitive method disregards this relation, nor does it allow for delays. Moreover it is wasteful of time, since the observer during one study can record the times of but a portion of the elements and is obliged to take other studies to find the unit times of the rest.

The repetitive method should only be used when the analyst is making a number of detailed observations of one motion of an operation with a view to its improvement.

4. *Accumulative Method.* There are two other methods for taking times which are adapted to special cases—the re-

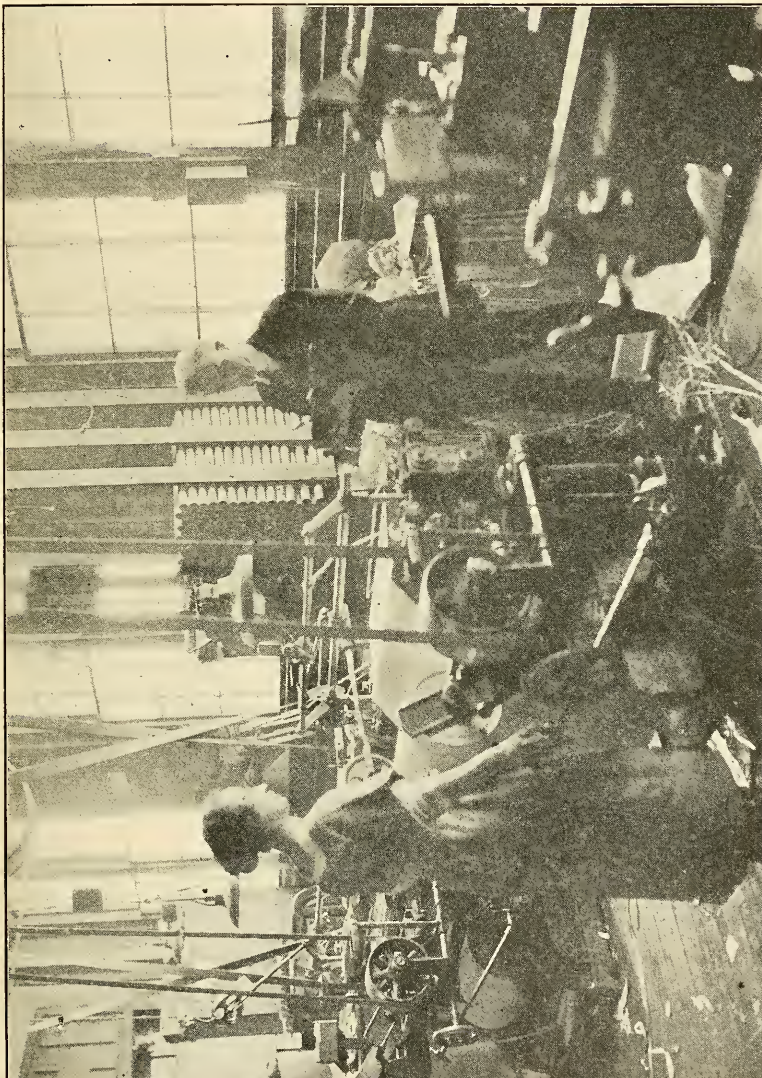

Figure 29. Observer in a Poor Position for Taking a Time Study

cording of elements which are "very fast," occupying between .003 and .02 minutes. These are the accumulative and the cycle methods. According to the accumulative method, the observer uses two or more stop-watches, the number depending upon his ability and the length of unit times, and keeps each watch for a separate element. Assuming that the symbols of the elements are, a, b, c, d, e, f, the first watch is started at the end of element f and stopped at the end of element a. Simultaneously with stopping the first watch the second watch is started at the end of element a and stopped at the end of element b. Both readings are then entered on the time-study sheet, and both watches are thrown back to zero ready for repeating this routine, which process is repeated at least 20 times. Since the escapement of the watch allows the hand to make 3 forward moves each .01 of a minute, by stopping the hand the reading of the element may be recorded to .003 of a minute. The sum of the readings of the individual elements may be checked by taking an over-all time study of the complete cycle.

5. *Cycle Method.* A cycle consists of a given number of elements. For example, there may be 4 elements involved in an operation—a-b-c-d—and these 4 elements taken together represent a cycle. The cycle method for taking the unit times of these elements consists of taking the times of the sum of all the elements less 1 element. The following equations represent the method.

An example to illustrate the method of computation is given below:

Equations

$$
\begin{array}{lrrrrl}
(1) & a + & b + & c & & = 0.06 \\
(2) & & b + & c + & d & = 0.05 \\
(3) & a + & & c + & d & = 0.07 \\
(4) & a + & b & + & d & = 0.06 \\
\hline
(5) & 3a + & 3b + & 3c + & 3d & = 0.24
\end{array}
$$

Dividing equation (5) by 3 gives equation (6):

$$(6)\ a + b + c + d = 0.08$$

Subtracting equation (1) from equation (6) gives the time value for element d:

$$(1)\ a + b + c \qquad = 0.06$$
$$d = 0.02$$

Similarly the time values for elements a, b, and c can be determined.

Carl G. Barth discovered the fact that the number of elements of a cycle which may be observed together is subject to a mathematical law. This law is that the number of elements in any set must contain no factors, that is, the number of elements in any set must be divisible by no numbers which are contained in the total number of elements. The following table [1] was devised to show how many elements may be observed together in various cases.

No. of elements in the cycle	No. of elements that may be observed together	No. observed together that lead to a minimum of labor or is otherwise preferable
3	2	2
4	3	3
5	2, 3, or 4	3 or 4
6	5	5
7	2, 3, 4, 5, or 6	4 or 6
8	3, 5, or 7	5 or 7
9	2, 4, 5, 7, or 8	5 or 8
10	3, 7, or 9	7 or 9
11	2, 3, 4, 5, 6, 7, 8, 9, or 10	5 or 10
12	5, 7, or 11	7 or 11

Thus if a series of 5 elements be taken and observations made on 3 consecutive elements of these at a time, the following equations would be obtained:

[1] F. W. Taylor, Shop Management, 1912.

$$
\begin{array}{llllllll}
(1) & a + & b + & c & & & = A \\
(2) & & b + & c + & d & & = B \\
(3) & & & c + & d + & e & = C \\
(4) & a & & + & d + & e & = D \\
(5) & a + & b & & + & e & = E \\
\hline
(6) & 3a + & 3b + & 3c + & 3d + & 3e & = A + B + C + D + E = S
\end{array}
$$

or

$$(7) \quad a + b + c + d + e = 1/3\, S$$

Adding a to both sides of equation (7) gives:

$$(8) \quad a + b + c + d + e + a = 1/3\, S + a$$

Equation (8) may be written:

$$(9) \quad (a + b + c) + (d + e + a) = 1/3\, S + a$$

Substituting in equation (9) the value A and the value D for their respective equivalents as shown in equations (1) and (4), we have:

$$(10) \quad A + D = 1/3\, S + a$$

or

$$(11) \quad a = A + D - 1/3\, S$$

Similarly equations for determining the time for elements b, c, d, and e are obtained:[2]

$$
\begin{aligned}
b &= B + E - 1/3\, S \\
c &= C + A - 1/3\, S \\
d &= D + B - 1/3\, S \\
e &= E + C - 1/3\, S
\end{aligned}
$$

Machines for Time Study

To concentrate on the performance of each element and at the same time to read the stop-watch and record the readings on the note sheet is difficult. Some study has accordingly

[2] F. W. Taylor, Shop Management, 1912.

been given to the development of a mechanical device for recording the detail unit times of the elements. Experiment has proceeded along 2 lines:

1. Under one plan, a ribbon or strip of paper moves at a uniform speed, while a pen, touching the paper so lightly as not to interrupt the uniformity of the speed, makes a running mark on it. The pen point is attached to a lever, which at the completion of each element the analyst presses, causing the pen to make a break in the vertical line drawn. The completed record, therefore, forms a zigzag line. The space between each break shows the elapsed time. Given the speed of the ribbon, it is possible to read the time taken for each break, which represents the time of an element. If the ribbon moves for instance 20 inches to the minute, each .2 inch will represent .01 of a minute and can be read off by measuring the distance between breaks with an engineer's scale divided in tenths. The use of the machine is limited to operations where the elements always occur in the same sequence, since there is no way of making notes on the moving ribbon without interrupting the speed. If a delay occurs, it must be noted on a separate sheet; but there is danger that the analyst, when working up the study, will be unable to co-ordinate the unit times and the notes. A uniform sequence of the elements, combined with an insignificant number of delays, is so rare, that the stop-watch will still have to be used on the majority of the studies and so makes this device for taking studies of little value.

2. Under the other plan a time stamp somewhat similar to that used in stamping time tickets can be devised to register every .01 of a minute. An ordinary electric time-clock for stamping is shown in Figure 30 with an attachment for holding the sheets on which the analyst can record the symbol of the element and make the notes at the completion of each element. By this plan the observer presses a lever which stamps the reading on the time-study sheet. With the release

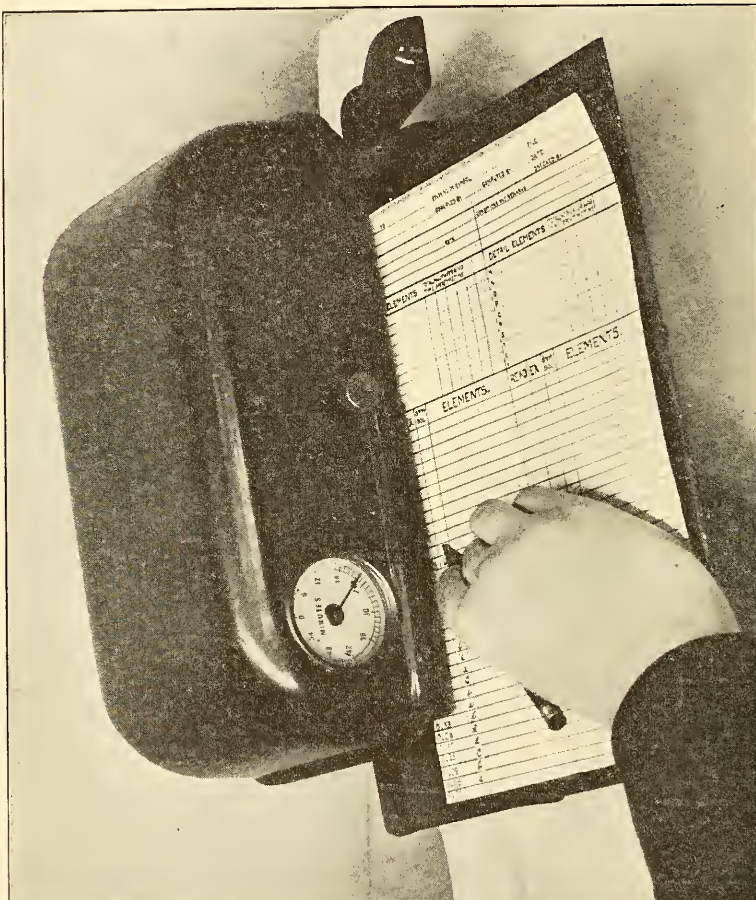

Figure 30. Electric Time-Clock with Attachment for Holding Time-Study Sheets

of the lever the paper is automatically pushed on one notch, ready for the next impression.

The clock is placed on a stand on wheels, so that it can be moved anywhere about the factory. The use of this time stamp will, of course, involve some expense in wiring the plant, in order to make it possible to make studies in every department.

Thus far no device has been worked out which makes and breaks electrical contact every .01 of a minute. A device is, however, being worked on at present, and will soon be on the market, making and breaking contact every .1 of a minute. There seems no doubt that the mechanical limitations of the time stamp can be overcome.

The advantage of using a mechanical device is that the observer is not obliged to give his attention to reading the watch, but can concentrate on the performance of the elements. It is of special assistance to the novice in taking fast times. There is danger, however, that such a device will become like a crutch—so necessary that the observer will scarcely be able to dispense with it—even in the cases where he is obliged to make use of the stop-watch because he does not have the equipment or because the factory has not been wired. He will therefore not develop the ability of the skilled observer, who can make the readings almost automatically.

Taking Time Studies

In spite of the possibility of mechanical devices the stop-watch is the most practical. The usual process of taking the times is for the analyst to select a skilled employee, watch him at work, divide what he does into its essential parts, and record the time at which each of these parts is completed. The length of each individual study is also a matter of judgment and skill. Individual studies may vary in length anywhere from 15 minutes to several days. Except for checking conclu-

sions, experimenting with different motions, or finding the effect of some one variable, short studies of 15 minutes to half an hour are never to be relied upon. The conditions may be exceptionally favorable or unfavorable at the moment, or the employee may be working at a spurt. Even if the situation is typical, the observer does not have a chance to enter into the swing of the operation and note on his sheet whether a cycle of elements is especially well performed. It is never advisable, therefore, to draw final conclusions as to the standards from short studies.

Although taking the times seems simple it calls for expertness and judgment in the observer. In reading the stop-watch, the mind must act instantly, in order to make a mental note of the watch-reading at the instant the element is completed. While at first this takes all the observer's attention, as he becomes more experienced he gradually finds that his mind becomes less and less conscious that he is reading his watch, and finally the readings are retained only long enough to make the record. He notes and records on the sheet the time of the element automatically—as one might button one's coat. The fact that his subconscious mind is taking care of the time elements long enough to record them, enables his conscious mind to analyze continually just what is happening. The combination of this ability to see and record all matter simultaneously affecting the times and to note the watch-reading in the approved manner is what makes a time study valuable as a definite contribution to the formulation of standards.

CHAPTER XII

COMPUTING AND ANALYZING TIME VALUES OF ELEMENTS

Considering Elements Separately

The first step in analyzing the studies and setting the standard is to determine separately the time values of each element. That is, the analyst for the moment should put aside all consideration of the time standard of the whole operation and concentrate on the unit times of each individual element and its distinct time standard. It is only by analyzing each element in this way that he can find the causes of variation in the time taken for the whole operation.

Importance of Analyzing Studies

It is as important for the analyst to employ the best methods in analyzing the studies element by element as in taking them, for his aim is to get the most satisfactory results in the shortest possible time. Working up the studies in the office is much more than merely supplementary to taking them. This third phase, analyzing the studies and setting standards, is usually the most difficult. Its conduct is tempered by the factors affecting the second phase—taking the studies—and the tentative conclusions drawn from the analysis in turn affect the taking of times, so that each is continually reacting upon the other. Both are fundamental to a complete job standardization.

When to Compute Studies

An analyst's mental equipment is of value in proportion to his ability to observe details and his capacity to retain them.

Any mental picture loses detailed definiteness as time elapses, especially if the passing picture is not reviewed.

The act of recording readings of the stop-watch at the completion of the elements should make a vivid picture of that process on the mind of the observer. If he works up the note sheets not later than the next day, he will be able, upon glancing over the time study of the previous day, to remember in considerable detail events which affected the amount of time taken. This power to remember is very valuable, because the analyst may not have recorded the circumstance at the moment it occurred, thinking the effect would be negligible, or perhaps he may have lacked the opportunity because the elements followed one another with such rapidity. If the notes are not worked up immediately, they lose some of their vividness; the observer's mind fails to retain the finer impressions which one picture after another has flashed upon it.

Making Extensions

The time-study sheet filled out by an observer shows opposite the symbol of the element the watch-reading that was noted at the moment the element was completed. This information appears in the column marked "Read." We will suppose that the watch has been kept running, according to the continuous method of taking studies, so that the readings represent continuous times. If this is so, then the time taken to complete any one element is the difference between the second reading and the first. For example, the time of the first element in the column, "Read," is 12.60; that of the second is 13.10. By subtracting 12.60 from 13.10 we have .50. This last figure appears in the column marked "Ex." The figures appearing in this column—the result of the mathematical process just described—are called extensions (see Figure 31).

It is fatally easy in making a long list of extensions to let the attention wander, and an error creep in. Since it is unlikely

Time *1:00* to *2:00 P.M.*
Study No. or Symbol *23*
Observer *W.E. Curley*
File *VER*
Date *10/18/20*
Checked by *R.S.B.*

Operation *Rip Veneer*

Department *Saw*

Location *S 1r*
Operator *Rank (Sawyer)* Rate *40¢ hr.*
Williams (Offbearer) *36¢ hr.*
Implements

Materials
15 Bundles 16 ½" x 56" - ¼" (25 pieces per bundle) = 375 pcs.

Conditions and Remarks
Study started upon completion of another size of veneer.
Watch read 12:60 at start of study.

a	c	e	f	g	h	j	m	s	s	s	sw	w	y
0.50	1.50	0.88	0.06	0.59	0.05	0.31	0.15	0.11	0.10	0.12	0.12	0.97	0.28
0.32						0.48		0.06	0.08	0.11	0.12	0.11	0.22
						0.50		0.10	0.08	0.10	0.16		
								0.09	0.09	0.10			
								0.11	0.09	0.09			
								0.10	0.11	0.10			
								0.09	0.11	0.16			
								0.09	0.07	0.09			
								0.08	0.09	0.09			
								0.10	0.07	0.10			
								0.10	0.08	0.11			
								0.11	0.07	0.08			
								0.10	0.09	0.09			
								0.16	0.09	0.08			
								0.09	0.10	0.10			
								0.10	0.09	0.10			
								0.06	0.18	0.10			
								0.08	0.17	0.10			
								0.05	0.11	0.08			
								0.09	0.11				
								0.09	0.08				
0.82	1.50	0.88	0.06	0.59	0.05	1.24	0.15	0.09	0.07	6.73	0.40	1.08	0.50
								0.07	0.09	0.29	-0.29	+.11	
								0.08	0.11	7.02	0.11	1.19	
								0.05	0.14				
								0.06	0.08				

Detail Elements	Total Time	No. of elems	Aver. Time	
a *Take out Blocks*	0.82			
b				
c *Shift Saws* (2)	1.50			
d				
e *Replace Blocks*	0.88			
f *Start Saw*	0.06			
g *Rip first handful and test width*	0.59			
h *Stop Saw*	0.05			
i				
j *Change Truck (per load)*	1.24			
k				
l				
m *Mark Order No. on load just ripped*	0.15			
n				
o				
p				
q				
r				
s *Saw handfull (Remove from truck jig saw)*	7.02	74	0.095	0.07
t				
u				
v				
w *Cut and removs wires (per bundles)*	1.19	15	0.079	
x				
y *Necessary Delays*	0.50			
	14.00			

Sy	Read	Ex	Notes
o	12.60		
a	13.10	0.50	
y	.38	0.28	
a	.70	0.32	
c	15.20	1.50	
e	16.08	0.88	
w	17.08	0.97	
f	.11	0.06	
g	.70	0.59	
s	.81	0.11	
s	.89	0.06	
s	.99	0.10	
s	18.08	0.09	
s	.19	0.11	
s	.29	0.10	
s	.38	0.09	
s	.47	0.09	
s	.55	0.08	
s	.65	0.10	
s	.75	0.10	
s	.86	0.11	
s	.96	0.10	
s	19.12	0.16	
s	.21	0.09	
s	.31	0.10	
s	.37	0.06	
s	.45	0.08	
s	.50	0.05	
s	.59	0.09	
s	.68	0.09	
s	.77	0.09	
s	.84	0.07	
s	.92	0.08	
w	20.03	0.11	
s	.08	0.05	
s	.14	0.06	
s	.24	0.10	
sw	.36	0.12	
s	.44	0.08	
s	.52	0.08	
s	.61	0.09	
s	.70	0.09	
s	.81	0.11	
s	.92	0.11	
sw	21.04	0.12	
s	.11	0.07	
s	.20	0.09	
s	.27	0.07	
s	.35	0.08	
s	.42	0.07	
s	.51	0.09	
s	.60	0.09	
s	.70	0.10	
s	.79	0.09	
s	.92	0.13	
s	22.09	0.17	
s	.20	0.11	
s	.31	0.11	
s	.39	0.08	
s	.46	0.07	
s	.55	0.09	
s	.66	0.11	
s	.80	0.14	
s	.88	0.08	
sw	23.04	0.16	
s	.16	0.12	
s	.27	0.11	
s	.37	0.10	
s	.47	0.10	
s	.56	0.09	

Sy	Read	Ex	Notes
s	23.66	0.10	
s	.82	0.16	
s	.91	0.09	
s	24.00	0.09	
s	.10	0.10	
s	.21	0.11	
s	.29	0.08	
s	.38	0.09	
s	.46	0.08	
s	.56	0.10	
s	.66	0.10	
s	.76	0.10	
s	.86	0.10	
s	.94	0.08	
h	.99	0.05	
j	25.80	0.31	Move Truck
m	.45	0.15	Mark
j	.88	0.48	
y	26.10	0.22	Clean
j	.60	0.50	
		14.00	
	+	12.60	
		26.60	Ext. O.K.

Sy	Read	Ex	Notes	Sy	Read	Ex	Notes

Figure 31. Time-Study Sheet with Extensions

that compensating errors will be made which will balance each other exactly, it is necessary to check the correctness of the extensions. The proper method of checking is to total them. If they are correct, the total will be equal to the last reading of the watch. It is better to do the checking column for column —as should have been done in the sample time-study sheet in Figure 31—since in this way an error can be run down almost at once. Otherwise, if there are 4 columns on the sheet and one error in the extensions, that one error cannot be located without starting again and checking all the columns until the one with the error is reached.

Making Tabulations

The next step is to tabulate all the elapsed times for each element under the symbol of that element. As each time value is posted, a vertical straight line should be drawn in front of the corresponding symbol. This will make assurance doubly sure that all the values are recorded under some symbol and that no value is entered twice.

All tabulations should be made on the face of the time-study sheet if possible. If not, they should be made on a sheet permanently attached to it. It is not advisable to make use of the back of the sheet for tabulations and calculations, even though it has the value of being an economic use of paper. The danger is that such figures will be overlooked by those checking the work.

When there are a great many values for each element, the quickest method of tabulating the unit times and getting the totals is to take them off on an adding machine which prints the figures on a ribbon or sheet of paper. The figures taken off on the machine can be pasted on a sheet of paper the same size as the time-study sheet in case the adding machine will not take an $8\frac{1}{2} \times 11$ sheet, or may even be pasted on the back of the time-study sheet itself, since they will be too conspicu-

ous to be overlooked. Pasting the strips of paper in this way keeps the files from becoming bulky and also prevents mixing up the strips.

Determining Machine Times

In work done by machinery the first factor to consider is the running time of the machine. The amount of time which the machine takes to complete a cycle of a given operation can be determined roughly by finding with a speed indicator the number of revolutions the machine makes per minute. The average of three 1-minute readings of the number of revolutions is ordinarily considered as the speed of the machine. There are, nevertheless, variations in machine elements. The speed is often materially altered by particular conditions and should be checked at various times of the day and under various circumstances. E.g., the starting of another machine driven from the same line shaft may slow down one already running. In a certain lithograph factory the starting up of a heavy calender machine required so much of the power that the speed of the other machines in the room was reduced almost 20 per cent. Occasionally variations of one sort or another in the stock will cause variations in the speed of a machine, on the same principle that an automobile may be able to go at a speed of 50 miles an hour on an extremely good road, yet be able to go only 30 miles an hour on a slippery or poorly cared for road. And who knows better than the workman how much the machine is slowed down at times from some such cause as the slipping of the belt? Under some conditions, as the electrical engineer is aware, even the electrical power fluctuates to some extent. Allowances must be made to cover such unusual conditions.

The time per revolution multiplied by the number of revolutions necessary to complete the cycle might be expected to give the exact information as to the standard time taken by

the machine for that cycle, but in reality it gives only the theoretical time. The actual time is considerably greater, since materials have to be put into the machine and taken out and since some delays will always occur.

Time Variations among Employees

If, then, we find variations in the time taken by a machine, what must we expect to find when we consider the time taken by a man? Too much stress cannot be placed on the effect of the character and state of mind of the workmen, upon their work, and on the fact that these variations should be studied by an experienced person who has been trained to do this work and who has properly demonstrated his ability to consider the human element in production.

The complexity of the problem can be realized when the fact is considered that, at the end of a day's work, it seldom happens that two men will have produced an identical amount of work, except in cases where employees have arbitrarily set for themselves what they consider the proper amount of a day's work. In the present discussion the situation where employees thus limit output is not considered, for such a situation will very quickly be perceived by the analyst after he has taken a few studies and it will then usually be remedied by appealing to the workers' sense of fair play.

The Personal Equation

The time taken by one employee, therefore, in performing any one element, as well as a complete operation, usually differs slightly from that of another employee. In speaking of the "personal equation," what is meant is this aptitude for accomplishing an element or operation in a less or greater time than some tentative base. This base, as pointed out in Chapter XI, should be, as a general rule, the times of the skilled employee. The times of the other employees may be compared

with the base in setting a standard within the range of the average employee.

It should be repeated again, inasmuch as the term "skilled employee" is so often misinterpreted, that when we speak of a skilled employee, we are not referring either to the employee who rushes around as if he were going to a fire and usually takes longer in the end, like the bricklayer in Chapter X, nor yet to the *exceptionally fast or exceptionally skilled* employee.

Up to the present, we have not mentioned the case of the exceptionally fast or exceptionally skilled employee because he is more or less of a rarity. Such an employee is a specialist in his line, has probably worked all his life at it, and—what is most unusual in any work—has known how to learn by experience. For instance, one man of this type, a carpenter, employed on work in Baltimore, Md., was accustomed to refuse to do anything but indoor finishing and other interior trimming in residences. He worked with such rapidity and skill that 40 per cent had to be added to all his unit times to bring them within the range of the ordinary skilled employee. Another exceptional man was a New York monotype operator. His speed was tried out on copy which had been given a number of employees in several printing establishments. It was found that he did the work in half the time taken by the other operators and could easily outdistance the demonstrator of the company manufacturing the machine.

Determining the Personal Equation

The purpose of determining the personal equation of various employees is twofold: (1) the unit times which are worked up from the time studies taken on the various employees are put on the same basis so that the results of the work of one employee may be compared with those of another; (2) the personal equation establishes the difference between the skilled and the unskilled employee, and through a study of

these differences the unskilled employee may be instructed and developed into a skilled workman.

The first purpose—to facilitate the comparison of employees—is exceedingly important. Let us assume, for example, that time studies are being taken on some of the different operations of weaving varying grades of cloth for a bleachery. Three studies are taken on a skilled employee weaving three grades of cloth as follows:

1. 44/40 — 38½ " — 8.20
2. 64/60 — 38½ " — 5.35
3. 80/88 — 39 " — 5.00

The first figure represents the number of the study; the second represents the number of threads per inch of warp; the third represents the number of threads per inch of woof; the fourth represents the width of the goods in the state in which it is received at the bleachery; the fifth represents the number of yards in each pound of goods.

Let us now suppose that three studies are taken on some less skilled employee who is also weaving the following three grades of cloth:

1. 48/48 — 38 " — 7.15
2. 64/60 — 38½ " — 5.35
3. 80/80 — 39 " — 4.00

In this case a comparison could be made between the two employees by comparing the times on that grade of cloth, viz., 64/60 — 38 1/2 inches — 5.35, on which both these employees had worked. If the skilled employee's time had been found to be 15 per cent less than that of the less skilled employee, a correction of 15 per cent would have been necessary in establishing the unit times of the less skilled employee so that his times could be correctly compared to those of the skilled workman. Of course no such correction as this of the times of the less skilled employee should be made on the basis of

merely one or two studies. The correction should be made only from a very careful analysis of a number of studies.

The case of laying cloth is much more complicated because it is group work, which always adds to the problem by increasing the influence of the human factor. The following statement reducing to common terms the times of the different combinations of the group, was nevertheless determined upon by the analyst taking studies with different men working together as a group. This statement represents the percentage of slowness of employees working in pairs laying cloth.

Employee	203	with	Employee 209	time	to	be	reduced	0	per cent
"	207	"	" 204	"	"	"	"	10	"
"	224	"	anyone	"	"	"	"	15	"
"	204	"	Employee 219	"	"	"	"	10	"
"	204	"	" 205	"	"	"	"	10	"
"	219	"	" 209	"	"	"	"	15	"

The times of Employees 203 and 209 are used as a basis.

Figuring to Three Decimal Places

The author recommends the practice of figuring the average of unit times to three decimal places, as shown in the examples in this chapter. This practice is of assistance to the time-study man and the analyst, for it shows directly that any figure with three decimal places is an average value and not a picked, individual reading. If the error should be made of averaging averages, which may be incorrect for a particular case, the error is not very apt to get by the analyst.

In plotting variables, the chances for making errors are often reduced to a minimum if the time values are figured to a common base of per square inch or per lineal foot. It is advisable in these cases to plot up the time, using three decimal places, for the error, if taken to the nearest hundredth when the time is multiplied by the total number of inches or total number of feet actually used by the workman, would be serious.

This practice is of great assistance in getting accurate results and is therefore justifiable.

Instructing Less Skilled Employees

The second reason for determining the personal equation of the various employees is that later on they will all be instructed and developed, if possible, into skilled employees. If the analyst can put his finger on the points at which the employee is weak, instruction can be concentrated on these points. The employee will be taught to use the motions employed by the skilled workmen. Bringing all the employees who are fitted to do the operation into the rank of skilled employees makes them of more value: (1) to themselves, because they are paid more if they are skilful; and (2) to their employer, because the cost of what they are producing is less per unit produced; and (3) to society as a whole, since a high standard of living is dependent upon a high standard of production.

Variations in Personal Equations

The variation due to the personal equation is shown on the opposite page in a study taken at random on a job which is typical of the variations found between a skilled employee, an average employee, and an unskilled employee.

The average employee took about 17 per cent longer on the total net time for the complete operation than did the skilled employee. The ratio was found to be quite consistent in the various other operations of inside carpentry, such as laying hard-wood flooring, laying base-boards, putting in stairs, and so on, not varying more than a small percentage one way or the other. This percentage was, therefore, adopted on this particular work in comparing the over-all times of the average employee with those of the skilled employee. The times of the unskilled employee were from 10 to 100 per cent greater than those of the average employee.

Put on Hinges and Hang Door	Skilled Employee	Average Employee	Unskilled Employee
(a) Move tools and implements	0.72	0.63	0.30
(b) Open box of hinges...	0.94*	0.47	1.65
(c) Lay off for hinges on door	1.50	2.08	1.55
(d) Mortise door for both hinges	3.10	3.96	4.82
(e) Place and screw hinges on door (3 screws per hinge).........	2.11	2.57	2.57
(f) Place door and mark jamb for hinges....	0.95	1.72	1.57
(g) Lay off for two hinges on jamb	1.51	1.88	1.50
(h) Mortise jamb for both hinges	3.06	3.63	4.27
(i) Place and screw hinges on jamb (3 screws per hinge)	1.80	2.98	2.55
(j) Hang door	0.90	1.05	0.55
(k) Make necessary adjustments to hinges...	3.82	3.57	7.45
Total net time for complete operations	20.41	24.54	28.78

* Waxed all screws.

The detail unit times of the elements on the operation given above vary considerably without any apparent relation. A further study of the detail unit times, however, will show that there is a definite relation between the time of the elements which relate to the skill of the employees. When an employee is 20 per cent faster in completing an operation than another employee it does not necessarily follow that he is 20 per cent

faster in performing each element; but it does mean that he performs practically every element in such a way as to make the total time for the job the shortest time possible. For instance:

1. In element (a) the skilled employee took the longest time, due to the fact that he placed his tools where they were readily accessible later on. The unskilled employee was the quickest on this element.

2. In element (b) the skilled employee took the precaution to wax all his screws. It meant a little extra time at the moment, but saved time later, on elements (e) and (i), where he placed and screwed the hinges.

A careful examination of this study, in fact, shows why the unit times taken by the skilled employee (including sometimes even those which take longer) should be the basis for the standard times.

The variation due to the personal equation is something which cannot be overlooked in determining the final standards, but allowance of some sort must be made to cover it. The answer to the problem of what extra allowance to make in order to provide the less skilled employee with a margin of safety depends on such matters as the character of the operation and the supply of labor.

Choosing the Right Men

In Dr. Frederick W. Taylor's [1] famous analysis of the operation of handling pig-iron, only one man in eight out of a gang of seventy-five was considered physically fitted for the work. This was unspecialized labor, and the analysis was made at a time when such labor was plentiful. It was possible, therefore, to transfer the seven men out of eight not fitted to handling pig-iron to work for which they were fitted, and to

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[1] F. W. Taylor, The Principles of Scientific Management, 1911.

hire and train a smaller force of physically fit men to take their places. In this case no allowance had to be made to bring the task set within the range of men not 100 per cent fitted for the work.

In industry it is not possible in general to hire an employee who can reach an ideal standard, so the standard must be set within attainable reach.

At the other extreme from Dr. Taylor's experiments on the handling of pig-iron is the operation of folding posters. Folding posters is seasonal work, and girls are transferred to it from other jobs when this kind of work is put through. During the season the original studies were taken, tall girls were employed, whose long arms were admirably suited to the necessary reaching. The following season, however, the only girls available for the work were short. They could not do it in the time allowed the first girls, because they could not do the reaching so easily. Studies were taken on the short girls, and an additional allowance was given them in which to complete the operation, because of the longer time it took them to reach across the table and the greater exertion entailed in reaching.

Analyzing Standard Time Values

The analysis of the time values of the elements shows what factors have an effect upon them and to what extent conditions of the operation, of the machine, of the stock worked upon and of the mill itself, are important, as well as the factor of the personal equation. All of these must be considered in analyzing the times taken by the element, in order to determine for each individual the time value which is to be the standard.

CHAPTER XIII

DETERMINING STANDARD TIME FOR THE OPERATION

Elements in Standard Time

The standard time in which an operation should be performed is made up by adding to the sum of the time of each element a percentage for necessary delays, plus a percentage for delays for the necessities of life, such as getting a drink, plus a percentage for fatigue. This may be expressed in a formula:

$$\left.\begin{array}{c}\text{Standard}\\ \text{time}\end{array}\right\} = \left\{\begin{array}{l}\text{Sum of the}\\ \text{standard}\\ \text{time of each}\\ \text{element}\end{array}\right\} + \left\{\begin{array}{l}\text{\% for av.}\\ \text{times for}\\ \text{necessary}\\ \text{delays}\end{array}\right\} + \left\{\begin{array}{l}\text{\% for av.}\\ \text{times for}\\ \text{necessities}\\ \text{of life}\end{array}\right\} + \left\{\begin{array}{l}\text{\% for}\\ \text{fatigue}\end{array}\right\}$$

The body of the standard time consists, as a rule, of the sum of the standard times of each element. The determination of the standard time for an element requires experience and judgment on the part of the analyst. It is not a straight average, not the unit time recurring most often in the better performance, nor the average of the means, although all these may play a part in determining it. It can be found only by carefully computing and analyzing the times of the individual elements as recorded on the note sheet, giving consideration to all factors affecting performance, especially that of the personal equation.

Average Time Values

The time value with which the analyst is concerned is the average time which an element should take, in contrast to

the average time which it actually does take. In order to determine this, all "abnormal values," i.e., those which are extraordinarily large or extraordinarily small, should be taken out for the time being. The average should then be found for the remaining values.

Abnormal Time Values

The usual causes of abnormal values are:

1. Some delay which will seldom occur.
2. Some mistake on the part of the observer which can generally be discovered by the fact that either the time of the element preceding or of the element following will be abnormal, while the sum of the two abnormal times will be about the same as the sum of the average times of these two elements.
3. Some variation in the performance of the element, which should not be repeated.
4. Wandering of the employees' attention.

Whenever possible, the analyst should make a note of any such cause during the progress of the study. Often, however, the unit times are of too brief duration to allow this, or it is not evident at the moment that anything out of the normal is occurring.

An absolute rule cannot be laid down for determining what are called abnormal time values, because of the fact that each element should be considered upon its own merits. As a general rule, however, it can be said that the abnormal times should not be used when determining average values; but that gross or straight average values should be used when the elements show variations from causes which cannot be prevented. In general, gross average time values should be used, retaining the abnormal time values under the following conditions:

1. Elements which occur in construction work, like excavating, construction of buildings, etc.
2. Elements which occur on more or less non-repetitive work, such as mill-wright's work or repair work.
3. Elements which depend upon a material which in itself varies to a degree, and which is manufactured by an outside concern whose product is not under the control of the manufacturer using it.
4. Elements which occur in connection with "group work."

Since it is not possible to lay down an absolute rule for determining abnormal time values, the way to make the determining of them clear is to give an example. The following case shows which values are considered abnormal and the reasons for so considering them.

The operation in question—loading, moving, and unloading a truck—consisted of three elements. The symbol of the first element was (a), of the second (b), and of the third (c). The times listed in the following tabulations represent those taken from an actual time-study sheet. The abnormal values are starred. They are not added in the total, with the result that the divisor is reduced by the number of starred values.

	(a)	(b)	(c)
1.	0.28*	0.49	0.08
2.	0.11	0.40	0.10
3.	0.10	0.45	0.09
4.	0.10	0.50	0.08
5.	0.12	0.52	0.12
6.	0.14	0.88*	0.11
7.	0.12	0.36	0.07
8.	0.13	0.56	0.09
9.	0.13	0.50	0.14*
10.	0.27*	0.32*	0.11
11.	0.12	0.52	0.10
12.	0.09	0.55	0.09

13.	0.47* (talk)	0.51	0.07
14.	0.09	0.60*	0.12
15.	0.11	0.42	0.11
16.	0.13	0.51	0.09
17.	0.12	0.49	0.08
18.	0.12	0.42	0.07
19.	0.11	0.50	0.10
20.	0.09	0.56	0.15*
	17) 1.93	17) 8.26	18) 1.68
Average	0.113	0.486	0.094

The reasons why the values are starred as abnormal are as follows:

Unit Time 1. (a) This is the first value after the operation was started. Part of this time is chargeable to "getting ready to start" and should have been so recorded.

Unit Time 6. (b) This time is very large, with no note on the time-study sheet to indicate anything unusual.

Unit Time 9. (c) 10 (a) and 10 (b). These elements were performed consecutively. Any one of them is distinctly out of line with the average time for the particular element. The sum of the times of all three elements, however (namely, $.14 + .27 + .32 = .73$) corresponds fairly closely to the sum of the average values of $a + b + c$ (namely, $.113 + .486 + .094 = .693$). In all probability, the observer allowed the times of these three elements to overlap instead of keeping them distinct.

Unit Time 13. (a) The reason for starring this value is self-evident. The observer noted the fact that the employee was held back by "talking."

Unit Time 14. (b) As with unit time 6 (b), there is no reason given why the value is extraordinarily large.

Unit Time 20. (c) This was the end of the operation. Part of this time is chargeable to "changing jobs."

In the case of the four exceptions cited above—in construction work, in non-repetitive work, in work where the variation in material cannot be prevented, and in group work—the abnormal values would not have been starred, with the exception of value 13 (a). In regard to this value the observer especially noted that the unit time included unnecessary "talking." If the employee had stopped working entirely while talking, the time could have been recorded as a separate time value.

Determining Abnormal Time Values

Individual cases will come up occasionally that require mature judgment. Time may often be saved in deciding whether a value is or is not abnormal by determining at a glance: (1) how much weight the value in question has in relation to the average unit time of the element; and (2) how much weight the element in question has in relation to the total time of the operation.

For example, in element (b) in the above list, three values are starred as abnormal. Let us assume that this element consists of "placing material in machine." There may be a difference of opinion as to whether the fact that the material is bulky makes it impossible always to place it in the machine without a hitch, or whether the bulkiness ought to have no effect on the time taken by the element. An experienced analyst would not spend long debating the pros and cons of the problem, unless he saw that the difference in the result was of enough moment to make deliberation worth while. In the case of element (b) the average with the abnormal values taken out is .486, whereas the gross average (i.e., the average including the abnormal values) is .500, which is only 3 per cent greater. The time taken by element (b), however, represents over two-thirds the total time of the operation. Great care, accordingly, should be exercised in determining the average time of this element.

If the element under consideration takes 80 per cent of the total time of an operation, the time allowed for its performance cannot be chosen too carefully. If, however, it represents only about 8 per cent of the total time, the maximum variation that could result would be considerably less than 1 per cent, which would be negligible.

Good Time Values

Every operation has a rhythm, so that the worker swings from one element into the next without a jar. The tempo of the rhythm or swing varies, even in the same person, under seemingly identical conditions, with such factors as his state of mind, health, or fatigue. All of these things affect the time of completing an element. The result is that the average times may vary considerably in different studies. It has been found by years of experience that, although the average times vary, good times picked from various studies are quite comparable.

The term "good time" is used to describe a time of the shortest duration which occurs with a reasonable degree of frequency. Although the decision as to what constitutes a reasonable degree of frequency might at first appear to be a question of judgment, an example will make clear that there is a definite principle and method of determining the good times. To make clear what is meant by a good value, the same list of unit times is used that was used before, with the exception of column (a), to show what was meant by an abnormal value. Elements (b) and (c) are chosen, because (b) represents a case where the unit times are of long duration, and (c) represents a case where the unit times are of short duration.

Good time values should not be confused with the practice of many so called time-study men of using the absolute minimum time in every case for each element. This practice cannot be too strongly condemned for minimum times are as a rule abnormally quick times.

(b)	
0.49	
0.40	
0.45	
0.50	
0.52	
0.88	
0.36	0.36 = Picked
0.56	good time if only the
0.50	first 10 values were
0.32	available.
0.52	
0.55	
0.51	
0.60	
0.42	0.42 = Picked
0.51	good time if only the
0.49	last 10 values were
0.42	available.
0.52	
0.56	

17)8.26

0.486 = Average time

0.42 = Picked good time when all 20 values are available.

(c)	
0.08	
0.10	
0.09	
0.08	0.08 = Picked
0.12	good time if only the
0.11	first 10 values were
0.07	available.
0.09	
0.14	
0.11	
0.10	
0.09	
0.07	0.07 = Picked
0.12	good time if only the
0.11	last 10 values were
0.09	available.
0.08	
0.07	
0.10	
0.15	

18)1.68

0.09 = Average time

0.07 = Picked good time when all 20 values are available.

For element (c) .07 is the picked good time when considering the 20 values. It happens also to be the minimum time, and occurs three times. Had it occurred only once, or 5 per cent of the time, .08 would have been selected instead. In the upper half of the column there are only ten values, and .08 occurs twice, together with an .07 and some .09 values. .08 is accordingly picked as the good time for these ten values.

For element (b) .42 is the picked good time of the twenty values, since .36 occurred only once. Had there been only ten values as in the upper half of the column, .36 would have been selected.

The good times are of assistance in determining the average times to use, because they are less affected than the average times by temporary conditions. The average times and the good times should be plotted independently and the deductions drawn separately. They should then be compared. Where there is any radical difference in the conclusions drawn, further study will reveal the cause of difference. The method of comparing good and average times will be taken up again later, in the paragraph on determining curves of variables. From this discussion it will be evident that the good times are used as a gage to determine the correct relation between the unit times of variable elements.

Constants

In many operations there are elements called constants which do not change with the varying requirements of a given order. A typical constant is the element of starting a train. It makes no difference whether the train is about to set out on a three or a three-hundred mile trip. The time it takes for the train to start and get up momentum should always be the same if all conditions of cars, track, weather, and the like are identical. For this reason the element of starting a train may be called a constant. There are constants in almost every operation. For instance, in the operation of laying cloth, the element of "obtain shears" is a constant.

The observer simply lists, under their respective heads, the average and the good unit times of the constant element, from the various studies. Analysis will then be made in order to determine the correct time for the element.

Variables

The majority of elements are variables, which are not so simple to analyze as the constant elements, since a variable is an element which changes according to the requirements of

any given order. In the operation of laying cloth, for instance, the element of straightening is a variable.

Determining Standards for Variables

A list for the variable of a number of average or good times means nothing, because it affords no basis of comparison. Take, for instance, the variable of walking. The amount of time taken depends, for one thing, on the distance walked. It requires much less time per foot to walk 30 feet than it does to walk 10 feet. If the analyst who studied the walking element in laying cloth had listed all of the times of walking, the list might have looked somewhat like the one below:

Time in minutes	Distance walked in feet	No. of time study
0.04	6	1
0.12	32	2
0.09	22	3
0.05	12	4
0.07	16	5
0.03	6	6
0.05	8	7
0.14	34	8
0.10	22	9
0.07	16	10
0.04	6	11
0.09	20	12
0.11	30	13
0.08	18	14

One glance at the figures shows that they are practically meaningless when tabulated in this way. It would not be possible to determine from this tabulation the time to walk any given number of feet not included in the list. The best way of arranging these figures so that they can be easily read is to plot them in graph form on co-ordinate paper.

The unit times of a variable element can be compared readily only if they are plotted on a co-ordinate paper, showing the variation in time against the corresponding variation in the element, so that the law connecting the two is evident. The time may be plotted on the abscissa, or the horizontal scale, against the number of feet on the ordinate, or the vertical scale. Then the time for any given length may be found by following the point for this length upward until the curve is reached, and then reading on the horizontal scale at the left the time opposite this point on the curve. In the variable of walking given above, the variation in time in minutes was plotted against the number of feet walked. A curve shown in Figure 32 was drawn by plotting the values given above, which makes it possible to determine the time required to walk any distance from 4 feet to 32 feet. To walk 12 feet, for example, would require .04 minute, while to walk 24 feet would require .09 minute.

After several time studies have been taken on any operation, and the extensions and tabulations made, each variable should be considered, in order to determine how to plot its unit times. The time values must be plotted in such a way as to show the relation of the time taken to the length, width, surface, area, weight, or whatever factor is the cause of the variation. The time may be plotted on the vertical scale and the length, area, or other determining factor or factors may be plotted on the horizontal. An example of plotting time against length is shown in Figure 33 where the curve was drawn to show the time for cutting paper. From this curve the time to make the cut may be found for any given job.

Comparing Points in Curves

Considerable time may be saved by noting opposite each point as it is plotted the study number, the employee's number, and any fact of importance. Take, for instance, the variable

element of "straightening," in cloth. As soon as several studies have been taken, the analyst should commence to plot the time values, using the time in minutes against the length

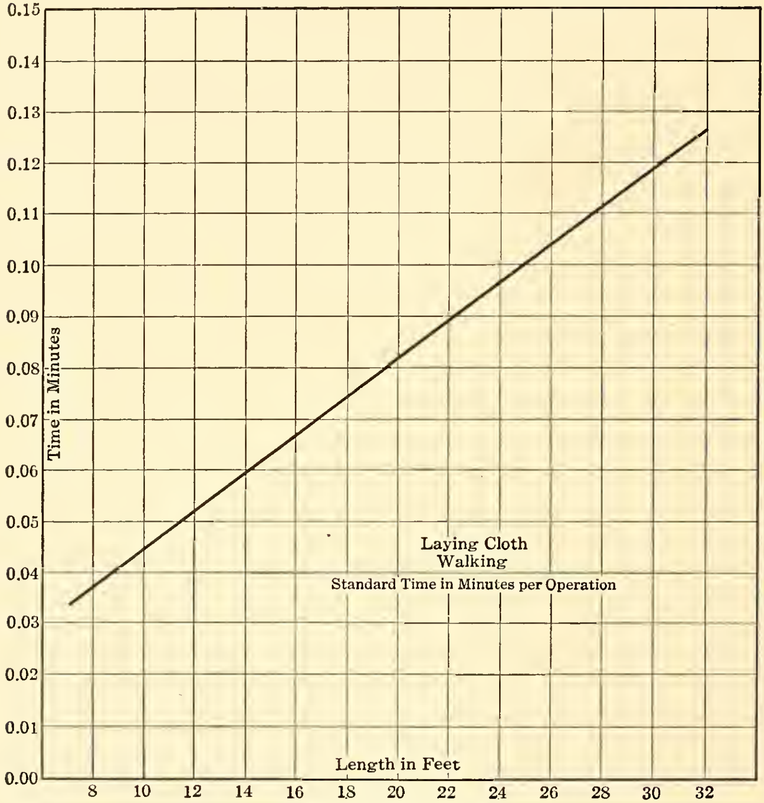


Figure 32. Graphic Curve Showing Time Necessary to Walk from Four to Thirty-Two Feet in Laying Cloth

in feet. He will also note, opposite each point entered, the study number or any fact which appears significant. As new time values are found from the studies, he will plot them also. The fact that a number of the points have already been plotted

will be of assistance, as additional points are entered. The time values previously entered, with the notes opposite, will afford a basis of comparison for each new value. If the new

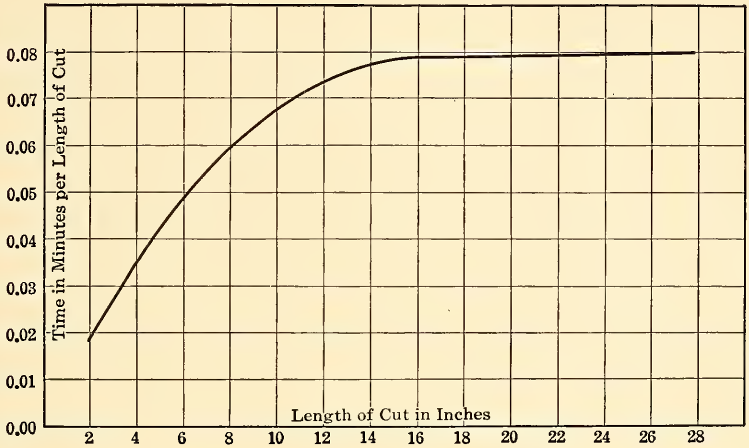


Figure 33. Graphic Curve Showing Time Taken to Cut Paper According to Length of Cut

point is out of line with the others, this will be evident and the analyst can investigate the reason at once. He may find that the cloth is of a slightly different grade and that a separate curve must be drawn for straightening this grade; or he may find that the group is poorly teamed up, in which case he can make a correction for the factor of the personal equation which will probably bring the point within range of the other points. In any case it will be possible for him to make an additional note in explanation. Extraordinary time values are shown up immediately by this method.

Good Times as Check on Curve

It is not always evident what curve to draw through a number of points, for there may be several which could be

drawn. Figure 34a and Figure 34b show examples of the different curves drawn for the same unit times of the element of "pulling cloth." It is sometimes practically impossible by simply looking at two curves, such as those in Figures 34a and 34b, to say at once which is correct, no matter how experienced the analyst may be. The curve which the novice would choose would invariably be the one representing his attitude toward the work. If he were inclined to give the workman the full benefit of the situation he would choose the curve in Figure 34a. If he were more interested in striking an average he would choose Figure 34b. An experienced man in giving a decision would prove which curve was correct. He would plot up his good times, as in Figure 34c and draw in the curve. Then he would superpose Figure 34c on Figure 34a and on Figure 34b, so that they would coincide as nearly as possible in terms of length. In this way he would prove Figure 34a to be correct for shape and direction. It is in an analysis of this kind that the value of plotting up the good times is evident.

The percentage of increase of the curve of the average time over the "good" curve will run, as a general rule, between 15 and 35 per cent where the operations are partly hand and partly machine. On machine work, with almost no hand work, there will be very little difference; while on an operation which is done entirely by hand the percentage of difference will be nearer 50 per cent. Experience in many kinds of industry and many kinds of work shows consistently that the two curves, the average and the good, will be symmetrical and that the average values will be the greater by approximately the same per cent from one end of the curve to the other.

Plotting Variables

The method of procedure in determining the proper curve is briefly as follows:

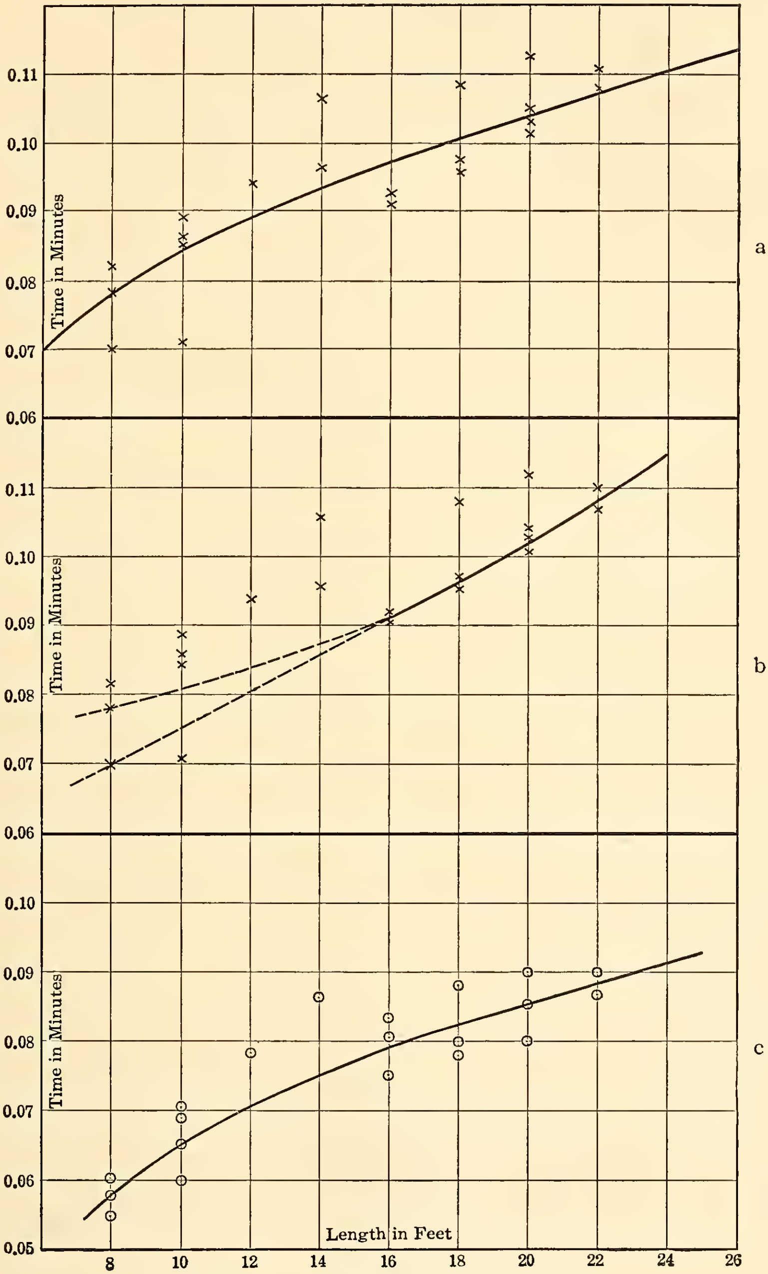


Figure 34. Unit Times for Pulling Cloth

1. Compare the curve drawn through the points of the good times with those drawn through the points of the average times, by superposing one curve on the other.

2. Figure in percentages the increase of the average times over the good times for the minimum, average, and maximum points of the curves.

If these percentage increases are practically uniform for all three conditions, it is safe to assume that the average curve chosen is the correct curve. If these percentage increases are not commensurate with each other, investigate the reasons by referring to the original time-study sheets, if necessary, and even in certain cases by taking some additional studies. The correctness of the deductions will be established infallibly by means of the new values. The time taken in checking up and verifying conclusions is time well spent, because it will give the analyst complete confidence and will insure the correctness of the standards.

Orders for the full line of a product do not always come into a plant at one time, convenient as this would be for the analyst. As a result it is often impossible to set standards for all conditions affecting the variable elements at the time the original analysis is being made. This is to some extent true in every business, and especially so where there are many special orders or a line of goods of extreme styles, or where the work is seasonal.

Exterpolating Standards

Sometimes the effect of all possible conditions on the time of an element may be estimated by extending the curve, that is by exterpolating. This has been done in Figure 35 for the element of pulling cloth. Points have been exterpolated on the curve of the average times, to show how many minutes would be required up to 34 feet in length. This method is, however, more or less indefinite. As shown in Figure 35, it is

difficult to say which of the two dotted lines is correct. Even when time values are found by exterpolation, the analyst should keep track of the nature of the orders coming in. When an order comes through which covers some variable whose

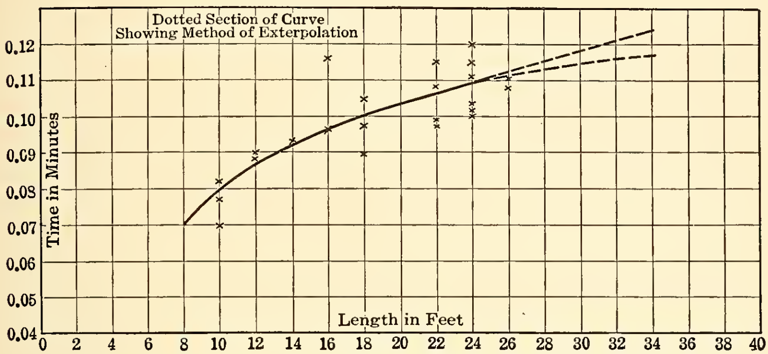


Figure 35. Graphic Chart Showing Method of Exterpolation

value he has estimated by exterpolating, he will immediately take steps to have the proper time studies made and to have these studies compared with the more or less tentative conclusions reached.

Exterpolating to determine extreme values is useful because it is often advisable to put the standards into effect before all possible conditions are determined. If the analyst waits until all possible conditions have been studied, the company loses the benefits of increased production and the employees the increase in wages.

"Guess" Allowances

The percentages to allow for delays, necessities of life, and fatigue should not be "guess" allowances of predetermined percentages on the sum of the times of the elements, as is too often done. One "guess" allowance is often intended to cover not only actual delays, but the inevitable slowing up

of the employee's speed when he is not under the artificial stimulus of observation. Both the fatigue and delay allowances should be kept distinct. The fatigue allowance should be sufficient to bring the standard time to the point where it is possible for the employee to maintain it year in and year out.

Necessary vs. Unnecessary Delays

Not only should the delay allowance always be kept distinct from the allowances for necessities of life and fatigue, but unnecessary delays should not be confused with necessary delays. It is difficult to make a general classification of delays, since the conditions in different operations, different factories, and different industries, vary greatly, making what would be necessary in one case unnecessary in another. Unnecessary delays constitute avoidable lost time due to such conditions as a wrong truck, or due to conditions not yet corrected. Necessary delays may in general be said to result from particular conditions which occur rarely. The employees, for example, may not always be able to handle the stock in just the right way, and if so, allowance should be made for this fact.

In determining the standard time, it is very important that the observer should have kept distinct the elements and delays incidental to the performance of the elements, listing each under the approximate symbol. Otherwise it will not be apparent from the studies why the time values of the elements vary and to what extent the additional time taken in some cases was due to a necessary delay. It is often difficult for the novice to keep the delay factor separate from the actual performance of the element. In one case an assistant in a study on an operation in the clothing industry showed delays amounting to only 2½ per cent, which, considering the nature of the operation, appeared surprisingly small. Accordingly the analyst checked the study by himself, taking a study on the same operative

doing the same work under the same conditions. The total time on the operation was practically identical on the study taken by the assistant and that taken by the analyst, but the analyst's study showed delays amounting to 16 per cent while the delays recorded by the assistant showed only 2½. The assistant, as it proved, had lumped in many delays occurring during the performance of an element as part of the time value of that element. The conclusions which would have been drawn from the assistant's study and the standards set thereby would have been incorrect had not the analyst taken the time to check the work of the assistant and run down the inaccuracy.

Allowance for Necessary Delays

The percentage for the necessary delays should be determined in the following way. First, make a tabulation of the total times taken in performing the work as shown on all the time-study sheets, including the time for necessary and unnecessary delays. Then tabulate the total times of the necessary delays, and in a separate tabulation set down the total times of the unnecessary delays. The net time for performing the work is determined by subtracting the time in the second tabulation, of the necessary delays and the time of the unnecessary delays in the third tabulation, from the total time of the first tabulation. This may be expressed in a formula:

$$\text{Net time} = \left\{ \begin{matrix} \text{Times shown} \\ \text{on studies} \end{matrix} \right\} - \left\{ \begin{matrix} \text{Necessary} \\ \text{delays} \end{matrix} \right\} - \left\{ \begin{matrix} \text{Unnecessary} \\ \text{delays} \end{matrix} \right\}$$

Second, figure the percentage of necessary delays by dividing the time of the necessary delays by the net time, multiplied by 100 in order to get the percentage.

$$\frac{\text{Necessary Delays}}{\text{Net Time}} \times 100 = \text{Per Cent of Necessary Delays}$$

Abnormal seasonal conditions should be taken care of by making a study of them at the period when their effect is most pronounced. Extra allowances must be made to cover them.

On the plating operation in a paper mill, i.e., the operation which puts a linen finish on stationery, the seasonal condition occurs during the winter months. Static electricity is generated through the friction of the paper with the linens and zinc plates going between the rolls of the plating machine and remains in the paper with the result that the paper sticks to everything it touches. It was found through study that during the winter months 10 per cent should be added to the standard time to cover this condition.

Allowance for Necessities of Life

The amount of time to be allowed for the necessities of life varies considerably with the character of the operation, and in some cases even with the season of the year. In construction work, for example, which has to be done out in the sun without any shelter overhead, the workmen will require a great deal larger allowance in hot weather for taking many drinks of water, wiping off perspiration, and so on, than they will require in cooler weather. Thirty-three and one-third per cent was found to be the amount required on a construction job for these necessities of life whenever the men had to work out in the hot sun and the temperature was over 90 degrees.

Allowance for Fatigue [1]

In this chapter, fatigue is considered only from the point of view of the necessity of determining what percentage to allow for rest on the particular operation after every effort has been made to reduce any strain involved. The problem of fatigue in its large aspects, and the means of determining and reducing its seriousness, will be treated in the next chapter.

[1] For discussion of fatigue, see Chapter XIV.

There are two points which should be considered in determining the amount of fatigue, in any given operation.

The first point to consider is the number of studies taken. If the operation is complicated, the analyst will have on file a great many studies covering all the different periods of the day. These will give a fair average of fatigue at all hours.

The second point to consider is the supplementing of the detail studies by over-all studies taken during a period of several days. The analyst follows the jobs through, informs himself exactly as to what is occurring and notes all abnormal conditions. The over-all studies will help to point out the possible danger of cumulative fatigue.

In operations which have a great deal of variety, the nature of the work provides rest automatically. The fatigue factor, therefore, is small on such operations, usually not more than 5 per cent. In other operations, such as those involving considerable danger if the workman relaxes his attention, or those in which there are fast moving parts continually passing before the eyes, the percentage of fatigue is much greater. It may amount to as much as 50 per cent. The relation of hand to machine work is still another thing which determines the amount of fatigue. There are some operations which involve strain, mental and physical, which cannot be relieved and therefore must be allowed for. Occasionally, fatigue allowance has required as high as 100 per cent of the working time of the operation.

The determination of the fatigue allowance and its addition to the total, complete the determination of the standard time.

CHAPTER XIV

FATIGUE

Determining Fatigue Allowance

Although fatigue is an important factor in industry it can be properly taken care of by the competent analyst. The standard time for performing an operation consists, as described in the preceding chapter, of the sum of the times of the elements plus percentage allowance for necessary delays, necessities of life, and fatigue. Of all the allowances, that made for fatigue is the most complicated, and therefore the most difficult to measure. Nevertheless job standardization, by showing exactly what is involved in each element of an operation and by showing the exact conditions of performance, provides a basis of knowledge as to the amount of rest needed to protect the average workman from fatigue. The fatigue allowance varies with each operation as well as with each factory thus requiring an exact determination for each particular case.

Serious Import of Fatigue

Both from the point of view of maximum production and from the social point of view fatigue is a serious matter. The individual who is fatigued cannot do such good work or so much as if he were not fatigued. He is unable to keep his attention concentrated on what he is doing; he has not the necessary patience. The results of fatigue often show themselves before the individual is conscious of being tired. They become more apparent, however, as his weariness increases. The work is not turned out at the former speed, and should it require careful handling the spoilage is greater. As the quality of his work deteriorates, so do all his actions show the

result of his physical depletion. He becomes irritable, he cannot digest his food, and he is unable to resist disease. If he is tired beyond the point at which he can regain his strength in an hour, over night, or even over the week-end, he has reached a point of "cumulative fatigue," and if work tires a man so that he suffers from cumulative fatigue there is something wrong with the man or with the work.

There are other reasons which have brought the subject of fatigue into the foreground of public attention. Workmen stress this unknown factor in order to safeguard themselves against unregulated pressure for greater production; the unions sometimes use it to maintain standards of production which allow the least skilful and slowest workman to earn a decent wage. Philanthropists interested in the welfare of the laboring class unwarrantably imagine that workmen are being driven to the limit of physical endurance.

Despite these considerations, fatigue is not the factor it is commonly imagined; general progress in industry has lessened fatigue-producing conditions.

One extremely important safeguard against fatigue that has gradually come into use is the decrease in the hours of labor. The 12-hour day, once general, now lingers on in comparatively few industries. Some states limit the hours of women workers to 48 hours a week. The 8-hour day is accepted as the government standard. Under the shorter day it is generally possible for a man to do more in an hour without wearing himself out; the pace does not have to be sustained so long and the time for rest is greater. Shorter hours have in some instances proved economically practicable and have helped to lessen fatigue.

How the Employment Department Reduces Fatigue

Fatigue is also guarded against in factories that use modern methods by means of the employment department. This de-

partment under the direction of a competent head has the qualifications needed for every job card-indexed and filed. When help is needed the interviewer can choose intelligently a man fitted for the job. By such means as this a blacksmith is not given a watchmaker's job, nor is a tubercular employee put to work where dirt or abrasive particles are in the air. The blacksmith's job is also made as easy as possible for him and methods are introduced to lessen the strain of close attention on the part of the watchmaker.

Mechanical Devices to Reduce Fatigue

Definite efforts have been made in progressive plants to lessen fatigue by mechanical improvements. The windows of modern factories are no longer painted to keep the employees from looking out and incidentally to keep out the purifying effects of air and sunshine. Neither are the windows nailed down, but are made easy for the employees to open. The relation of eye-strain to fatigue is given study, and provision made for proper lighting, both natural and artificial. The contrast between a factory built today and one built a quarter of a century ago is marked. The windows of the modern factory are large, the lighting is good, and the physical conditions are conducive to health. Good ventilation and good lighting can be achieved even in factories built before the importance of the physical equipment was realized. Cotton-mills have already introduced mechanical devices which carry off some of the lint, and humidifiers for conditioning the atmosphere.

Such safeguards show how certain loopholes through which fatigue may attack the employees have been closed. To prevent very great physical effort, to decrease the strain that at first is not so obvious, such as standing all day, or working on a bench that does not fit one's physical dimensions, carefully thought-out mechanical devices are introduced.

The Analyst's Problem

No matter how well conditions may be adapted to jobs the analyst finds that a residue of fatigue appears in every form of work.

In an attempt to cover all contingencies, by arriving at general laws, tests have been made both in laboratories and factories with but little success. These tests usually involve a method of showing relative production at various hours or under various conditions and draw the conclusion that a decrease in production is an evidence of fatigue. The best practical method of finding the amount of fatigue incident to the performance of each operation is to analyze that operation part by part, as is done in the course of job standardization, at the same time taking into consideration all other observable evidences of fatigue shown in the operation.

Utilizing Mechanical Methods

The analyst naturally turns to special account mechanical devices for lessening fatigue. Chairs of the right height and type may relieve fatigue when the worker has had to stand all day. Sometimes an employee may even tend two machines without walking from one to the other if his chair is placed on wheels that run on tracks. Where a regular chair is impracticable a collapsible stool attached to the machine may be pulled out and used by the employee. Trucking material may be eliminated for the operator by transferring that part of the job to a "moveman" who is hired for such work. A bracket attached to a truck used for carrying coils of wire did away in one factory with the strain of supporting the weight of the wire while moving it. On a certain operation where a girl used dies for cutting out labels a spring platform was used to reduced the force of the jar caused by her mallet (Figure 15). In many factories a large part of the heavy lifting and pushing done by men could be done by machinery.

Reducing Fatigue by Instruction

The analyst further assists in reducing fatigue by having the employees taught the best method of working. Some workmen use motions that involve a needless waste of strength and time, and it is the task of the analyst to introduce simplified methods—and then to see that each workman uses them.

A case in point is the operation of cutting paper. The size of a sheet before cutting may vary from 40 inches × 60 inches to 20 inches × 30 inches. The weight of paper for 500 sheets, or a ream, on a 17 inches × 22 inches basis, may range from 30 pounds up to 180 pounds. The size of the sheet after cutting may be no more than 4 inches square. The stock may have been put through the printing press a dozen times, so that it must be handled with the greatest care to guard against spoilage, which otherwise would be large. It was found by analyzing the work of a number of cutters that each one lifted a different amount of paper to the machine, some lifting it with the sheet flat, others folding one edge over, and still others making a double fold. Some took 3 lifts to fill the machine while others took 6. A study of all the conditions made it possible to decide the correct quantity to lift with the least effort. The amount of wrist and arm strain required by the method some of the men were using was so great that had this method continued in use only men of exceptional strength could have done the work for any length of time.

Rest Periods

The analyst may also find that it is advisable to give a fatigue allowance in the form of rest periods of a definite length at definite hours of the day. Where rest periods have been satisfactory three conditions have been observed:

1. Standards of performances have been set.
2. The rest periods have been adapted to the needs of each operation separately.

3. The co-operation of the employees has been gained, so that they observe the rest periods voluntarily.

Rest periods without standards of performance are meaningless. The management, knowing practically nothing about the operation, should not attempt to interfere at this point. The employees are working with different methods, at different speeds. If they are on day-work most of them are probably resting much more than necessary; while if they are on piece-work, methods and paces are so different that each will need his rest period at a different time of day.

Even with definite standards, the rest periods should be adapted to the needs of each operation separately. A rest period of ten or fifteen minutes in the middle of the morning and afternoon may be necessary on one operation in a department, while on another operation it may not be nearly enough or come too late to be of much benefit. One operation may need frequent shorter rest periods, and another require one long stretch of complete relaxation. As a rule, however, it is practically impossible to enforce rest periods when they are not adapted to each operation separately.

It is absolutely necessary that the employees themselves be taught to appreciate the value of rest periods and to take them voluntarily. It is impracticable to force each group of workmen to stop work at a different hour of the day; and since they are paid by the amount they produce they will not stop unless they realize that in the long run the rest is to their own advantage.

Percentage Allowances for Fatigue

In any case, the analyst should follow the practice of making a fatigue allowance. This allowance is a percentage of the operating time as determined by time study and job analysis. The percentage is found by analyzing the time studies.

Sometimes it is necessary to make special studies to find the amount of fatigue involved in the operation. As a rule, however, this may be determined from studies already taken. If enough studies have been made they show conditions and consequent fatigue at all hours of the day—early in the morning, at midday, and in the low-tension hours around 3 o'clock. Long studies give a better evidence of fatigue than short, since during a short period the employee may have been working at a spurt, which he could not keep up week in and week out. Moreover it is a great help in determining the fatigue allowance if the analyst has familiarized himself with the operation at the start by taking an extended over-all study over a period of two or three days. The fatigue allowance is not standard but is adapted to the demands of the operation in question. The fatigue factor is small on operations having a great deal of variety, because rest is provided automatically, and therefore, the allowance may not be more than 5 per cent. On other operations, such as those involving considerable danger when the workman relaxes his attention, or those in which there are fast moving parts continually passing before the eyes, the percentage of fatigue is much greater. It may amount to as much as 50 per cent. Occasionally fatigue allowance has required as high as 100 per cent of the working time.

Use of the Follow-Up

The analyst also provides the employee further safeguard against overwork by reports of daily production. Any failure to earn the standard pay is, through these reports, brought to the attention of the analyst, who investigates to learn the cause of failure. In some cases the cause may be ill health, requiring medical attention. The analyst will also be on the watch for any cases in which the employee is exceeding the standard time by an extremely large margin, because this probably means that he is overdoing.

Fatigue should be considered on each operation separately. By means of mechanical devices and instruction in the easiest methods and motions of doing the work the analyst decreases fatigue. Irreducible fatigue is provided for by a time allowance. The danger factor of fatigue is thus reduced to the lowest possible quantity.

CHAPTER XV

CHECKING STANDARD TIMES

Testing the Standards

After the standard time for the operation has been determined by use of the formula discussed in the preceding chapter it must be checked before it is summarized, indexed, and filed. The standards set, however, are absolutely of no value unless the employees are able to work in accordance with them day by day, year by year, without increased physical or mental fatigue.

Consequently this checking is done in the factory, against actual output. If the conclusions are not proved by this test, the standards should be given a rigid examination, but it does not necessarily follow that they are wrong. There is no need of becoming panic-stricken if the employee, on being informed that a test is to be made to prove the conclusions, either beats the standard or fails to make it. This statement requires, perhaps, some explanation.

Beating Standard Times

If the standard time has been set so that the employees can make it day after day and year after year, it is always possible for a skilled employee "to let out a notch or two" and beat it by a large margin.

In a certain box factory, where packing cases are made for shipping goods, the workmen have repeatedly beaten the standard time by as much as 40 per cent by applying themselves with spurts of energy for the purpose of "snowing under" the men on the next operation. Figure 36 shows the results of a number of studies on the employees when working

at a normal pace and when working at a spurt. This does not indicate that the standard times were too high, since such spurting tends to overwork and should be discouraged. In another case in "framing"—i.e., rough carpenter work, such

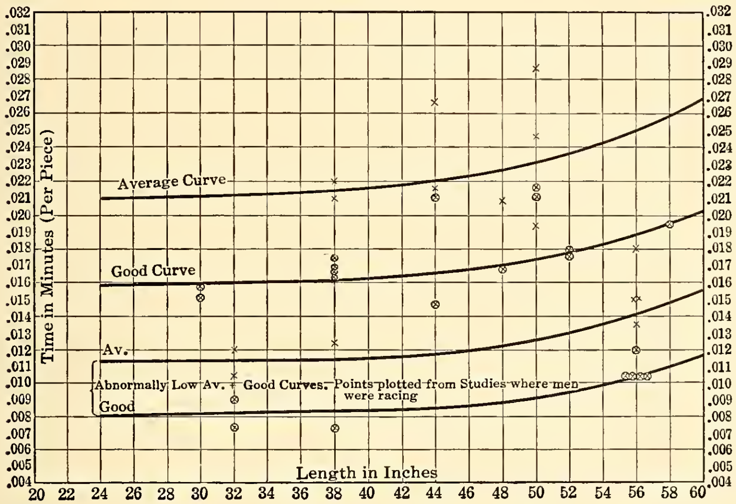


Figure 36. Time Studies of Workmen Working Normally and under Pressure

as cutting floor joints for wooden-house construction—the employees did the work in about one-half the standard time, because they wanted to prove, as they thought, that the standard times were wrong. The individual jobs—as, for example, framing a few joists around a stair-well—were very short. The men were given several jobs at one time, some of which took only eight minutes to complete. In cases of this kind they were expected to go directly from one job to the next. By working at top speed on the first day, the men finished a day's work in about half a day. If they had been allowed to continue at this speed, they would have exhausted themselves in a week or two.

The answer of the analyst to the first day's performance was to talk over with the workmen the foolhardiness of their procedure and show them by records of their own previous performance the reasonableness of the times allowed. On the second day he gave them job tickets for only a few jobs at a time, covering a period of approximately one hour's work. When they had finished these and came back for more tickets, he refused to give them any more until the time allowed for doing the work just finished was up. In this way he showed them how to keep up a pace just fast enough to complete the work in the standard time. He was convinced they would realize after they had tried it that this speed was the one they would be able to keep up day in and day out without detriment to their health. In this way the fairness of the standards was proved to the men, so that no further trouble was experienced when they were asked to work according to the standards.

Falling below the Standard

Occasionally the employee will react in just the opposite way, and will move around as if he were going at lightning speed and still fail to accomplish the job in the standard time. When an experienced analyst is making a check study, he will observe the work of the employee closely and will take enough notes to enable him to put his finger on the unnecessary movements and delays which drag out the work to an undue length of time.

The real cure for situations like this, however, rests in the co-operation between the employees and the analyst which results in mutual benefit to the employees and the company.

Variations of Minor Importance

The problem of determining what major elements to allow for the performance of a given operation is comparatively

simple, so that there is little danger that the analyst will neglect to consider any of them in his computation. There is danger, however, that he will not allow properly for a number of more or less minor elements, or elements which occur infrequently. For instance, a minor element, like putting oil occasionally on the side of a hand-saw to prevent it from sticking, may be a small item in point of time; yet if it is done, say, once every fourth sawing, it is of real importance in the total. The way to make allowance for this element without complicating the figuring by having an additional item to add to every fourth sawing is to divide the time for oiling by four and add this time to the standard time for the sawing element.

Checking Standards by Time Studies

In order to be sure that all the minor elements have been taken into consideration the final standards should be proved in the following manner by using at least three to six of the complete time studies on the operation. These three studies given below were picked out as samples of cases in need of adjustment. Take one study at a time and run a check as follows:

STUDY 1

	Minutes
1. Total time as shown on time-study sheet............	225.72
2. Unnecessary delays as taken off time study........	16.24
3. Time to perform the operation of 26 cycles omitting unnecessary delays	209.48
4. Time to perform the operation according to standard as set = 7.85 minutes × 26 cycles...............	204.10
5. Per cent increase of item 3 over item 4...........	2.6%

STUDY 2

1. Total time as shown on time-study sheet..........	429.18
2. Unnecessary delays as taken off time study........	31.17

3. Time to perform the operation of 43 cycles omitting unnecessary delays 398.01
4. Time to perform the operation according to the standard as set = 7.85 minutes × 43 cycles + .76 minutes 338.31
5. Per cent increase of item 3 over item 4.......... 18%

Study 3

1. Total time as shown on time-study sheet.......... 139.24
2. Unnecessary delays, as taken off time study........ 27.09
3. Time to perform the operation of 13 cycles omitting unnecessary delays 112.15
4. Time to perform the operation according to the standard as set = 7.85 minutes × 13 cycles + 4.49 minutes 106.54
5. Per cent increase of item 3 over 4................ 5%

If item 5 in any case shows more than 1 per cent difference the cause must be found. The reasons for the difference should be investigated along the following lines:

1. Was the figure for the unnecessary delays as used in item 2 correct? The unnecessary delays may have been included in the time values of the elements, instead of being kept distinct, or delays that were in reality unnecessary may have been tabulated on the sheets as necessary. In either of these cases, apply corrected figure to items 2 and 3.

2. How many abnormally large or small values were on this study? If many, by what amount? Figure this and apply correction to items 1 and 3.

3. Did any new factors enter into this performance? If so apply correction to item 4.

4. Was this study taken on a slow workman? If so apply correction to items 1 and 3.

Re-figure item 5 using corrected time of item 4, and if it still varies more than 1 per cent, the original time study should be reanalyzed and checked for probable error or for elements

which have not been properly considered in the first tables. It is a discrepancy such as this which necessitates the "proving up."

In study 1, the cause of the difference was the number of items encircled as "abnormal values."

In study 2, the cause of the difference was due to a combination of minor elements. One was trouble with the stock, another was that the employee studied used motions which were necessary to him, but which were not used by the other employees. Still another was that the machine studied was so located that it was not easy to get the stock in, a condition which should have been corrected before the standard times went into effect.

In study 3, the trouble was due to mechanical features of the machine, which were to be improved.

This proving out brings such features forcibly to the attention of the analyst.

Testing Causes of Delay

When delays are brought out definitely in this way it is possible to decide what procedure is most advisable. There are three courses open to the analyst:

1. Make the necessary small allowance to cover the delay.
2. Set a standard which will apply to the operation to be done before corrections have been made with the understanding that new standards will be set as soon as the corrections have been perfected.
3. Hold off setting the standard until all the conditions can be perfected.

Making Small Allowances

In the first course great care must be exercised not to take the path of least resistance and fail to investigate carefully

whether it is practicable to effect a cure in order to overcome the delay. It is by a 1 per cent saving here and another 1 per cent there that the total savings can be appreciably increased. This point is well illustrated in the setting of the standards for reeling and inspecting coated paper which is fully described in Appendix A.

The operation consists of trimming both edges of coated paper while it is being reeled from a large roll to another roll and inspected at the same time. The inspection consists of removing by tearing out all of the coated paper which has any imperfection on it and then piecing the two ends of the good paper together so as to make the roll of paper one continuous sheet. The improvements in this threefold work brought to light the fact that there was:

1. Increased output due to:
   - (a) Improved methods of saving time and labor.
   - (b) Bonus incentive.
   - (c) Graphical competition accomplishment charts.
2. Improved quality due to:
   - (a) Training operations.
   - (b) Making bonus dependent upon careful work.
3. Reduction in waste of labor and materials due to:
   - (a) Knowledge of how to handle material.
   - (b) Introduction of labor-saving devices.
   - (c) Creation of centralized planning department.
   - (d) Systematic care of machinery.

Before job standardization had been made on this operation the clerical work necessary for putting through the jobs and keeping the records required a clerk in the department, but it proved possible to transfer this work to the clerical force in the planning department, which was equipped to do it.

The percentages of saving by simplifying the clerical work were small—namely .74 per cent by preparing labels in the

planning department, 1.09 per cent by revising the job ticket, —but added to other small savings, such as 1.02 per cent by storing the operator's samples and tags at his bench instead of across the aisle and 1.14 per cent by using a spring clip in place of a hook—they give some idea how an accumulation of small percentages mounts up to quite a factor in production. The tabulation of estimated increases in output resulting from the changes is given herewith.

	Per cent of increase on previous annual output
Tender to change rolls and extra shafts:	
Feed roll	8.75
Finished roll	15.46
Elimination of wrapper on feed roll due to special truck	6.65
Preparation of glue and oiling machines	8.57
Ends slit for splices instead of folded and torn	5.52
Cleaning after hours by janitor	11.18
Band on finished roll replaced by gummed label	4.87
Labels prepared in planning department	0.74
Revised job ticket	1.09
Reduction in samples due to standardization	5.95
Samples and tags stored in operator's bench instead of across an aisle	1.02
Variable speed motor giving a uniform speed 59.1 per cent greater than previous average speed	8.67
Decreased down time due to better planning	12.10
Spring clip for counter instead of hook	1.14
Automatic return for threading paper through the machine	0.97
Total annual increase due to improved methods	92.68

Setting Temporary Standards

The second course, namely, the setting of a standard which will apply to the operation before corrections have been made, with the understanding that new standards will be set as soon as the corrections have been perfected, is advisable where:

1. The change is large enough, so that the employees will appreciate a corresponding change in the time allowed.
2. Production must be increased as quickly as possible in order to relieve congestion at this operation.
3. The day-work rate or the old piecework rates must be increased in order to satisfy the employees on their pay.
4. The changes cannot be brought about within a reasonable time, either because some research is first required or because one machine or mechanism must be developed, which must be tried out over a long period to determine its value.

In most factories the employees know what it means to have their day-work rate or their piecework rates changed under varying alibis, and as a result they are naturally suspicious of every change. In the past where the rates have been set haphazardly there were many justifications for making changes. On the other hand many changes were simply made to squeeze more work out of the employee or to decrease the amount he could earn. The experienced analyst realizes this only too strongly and only after mature consideration will he consent to set up standards which require an understanding with the employees that they will be changed as soon as conditions are perfected as outlined.

Although the third course, namely to refrain from setting the standards until all the conditions are perfected would be the ideal method to pursue, the method adopted must also be

practical. The considerations involved in the second course, such as the immediate need for increased production to relieve congestion, the pressure for immediate increase in rates, the length of the time before improvements can be made, these are the factors which determine whether it is practical to wait until the conditions in the third case are perfected.

Using Data to Make Needed Allowances

In addition to bringing the attention of the analyst to conditions affecting production which he might otherwise overlook, the checking of standard times also furnishes data from which to make special allowances for certain peculiar conditions in the case of failure to make the standard time due, not to the fault of the employees, but to the recurrence of these peculiar conditions.

CHAPTER XVI

DECIDING THE RATES ON THE OPERATION

Explanation of Rates

The term "the rates on the operation" covers both the amount of wages and the method used in paying the wages. Since the observations of the analyst have informed him more fully regarding the characteristics of the operation than any other member of the organization, it is for him to recommend to the management in what way and to what amounts the employees working on any particular operation should be paid. It is a practical question which he must settle at once, since it is of great importance both to the employer and to the employee.

Rates—Employee and Employer

The employee, being human and not working for his health, is interested first of all in the amount of money he may expect in his pay envelope at the end of the week. He is after that interested in the amount of work he is required to do in order to receive this pay. With these two factors before him—in addition to other factors not so tangible and of varying importance with different men—he believes he is in a position to decide whether or not the job interests him. He naturally also compares the amount of skill and effort required and the amount of pay he can earn on his job with the requirements and earnings for other jobs in the same factory and vicinity.

The employer as well as the employee has these same interests at heart, namely, to have an equitable adjustment between: (1) the amount produced as against the cost of producing (which includes wages), and (2) the earnings of the employees computed in accordance with the difficulty of the operation.

The employer is anxious that the employee should receive a share of the returns coming from increased production, where the returns have been brought about through the combined efforts of the management and the employees. He realizes the justice of paying the employees in proportion to the requirements—danger, monotony, application, experience, etc.—of their work. And job standardization makes it possible to determine the relative weight of these factors.

Methods of Payment

The first point to be considered is the development of a method of payment which shall be adapted to the operation to be paid for. There are many methods of payment, having different advantages varying according to the factory and the conditions. Some of these are day work, piecework, Towne-Halsey premium plan, Rowan premium plan, differential piecework, task and bonus, or time work with bonus. A thorough treatment of each of these, listing the advantages and disadvantages, would occupy considerable space, and would after all be only a recapitulation of ground already ably covered in a number of books and articles on the subject. The subject in this chapter is considered only as another step in work analysis.

The analyst should keep in mind that the fewer methods of payment introduced, the simpler and more effective will be the understanding the employees will have, and the easier will be the figuring and making up of the pay-roll. To have only one method of payment—or at most two, since day work cannot be entirely eliminated—is the ideal toward which every concern should strive.

Fitting Payment to Operation

The ideal of having only two methods of payment, however, is not always practicable or even always desirable. Its

complete realization might prevent a method more equitable, both to the workman and to the company.

Laying gold leaf for titles on book-covers may be cited as an example of an operation in which it proved more economical to adopt a complicated form of payment. The gold letters are imprinted on book covers in the following way: First, that part of the cover on which the letters are to be printed is wiped with a cloth containing a thin oil, so that the gold leaf will adhere. Secondly, several pieces of gold leaf are cut to the size required to cover the letters, and are then laid accurately by means of a gage. Thirdly, the cover is put into a machine similar to a printing press and is stamped with a hot die which comes down on the gold leaf and firmly sets the gold letters on the cover. The gold leaf not touched by the hot die can then be wiped off with a composition sponge from which the gold is afterwards reclaimed. The standard times of elements involved in laying gold leaf on book covers is represented in Figure 37.

The material, namely the gold leaf, is the largest item of expense, and economy is dependent upon the skill of the workmen in using the least possible quantity of it. For this operation, the method should be to pay the employee first for the saving of material, second, for the quality of the work, and third, for the actual quantity produced. In order to induce the employee to attend primarily to the saving of material a further proviso might be added to the effect that: (1) No reward for quantity will be paid unless the rewards both for saving in material and for quality have been earned; (2) no reward for quality will be paid unless the reward for saving in material has been earned.

Although an exception may be made to provide a special method of payment, such as the above, such a method should be treated as a special condition. In general a method of payment which is simple enough to be applicable to all of the

	Cutting Gold Leaf			Oil Covers, Place Gage, Place on Pile — Per Cover				Placing Gold Leaf —Per Piece			
	On Cushion			Back	Side			Back	Side		
	Place 1 Sheet	Cut 1 Cut	Turn Cushion		1/4 Side	1/4 to 1/2 Side	Whole Side	Imprint	Ordinary	Full Sheet	Inspection of Instructions
	Per Sheet	Per Cut	Per Sheet								
Standard time	0.15	0.03	0.01	0.15	0.15	0.18	0.19	0.08	0.08	0.22	1.50
Net time	0.11	0.02	0.01	0.11	0.11	0.13	0.14	0.06	0.06	0.16	1.10
Turn back blank leaf in gold book	0.02									0.02	
Tap and blow gold leaf over knife	0.03										
Place gold leaf on cushion	0.03										
Blow gold leaf out flat	0.03										
Cut gold leaf on cushion (measure)		0.02									
Turn cushion 90°			0.01								
Place covers on table (6 per bunch)				0.04	0.04	0.04	0.04				
Oil covers				0.02	0.02	0.04	0.05				
Place gage				0.03	0.03	0.03	0.03				
Lift and place gold leaf on cover								0.06	0.06	0.14	
Place cover on pile				0.02	0.02	0.02	0.02				
Inspect instruction card											1.10

Figure 37. Time-Study Sheet Showing Standard Times of Elements Involved in Laying Gold-Leaf on Book Covers

operations not on day work should be worked out and adhered to.

Day Work

The floormen and some of the men on general work are paid by the hour or day, irrespective of the quantity of work they do. Foremen are either paid in this way by the day, or else are on salaries. If they are on salaries, their pay is not in proportion to the time they put in at the factory, nor do they receive extra pay for overtime, but, on the other hand, they are paid uniformly despite absence on holidays, vacations, and because of sickness. Since foremen are on the one hand executives and represent the company and on the other hand are employees, it is not advisable that they be paid bonuses, except where there is some general profit or bonus-sharing plan throughout the factory. A system under which workmen on piece or bonus work receive more than the salaried foremen is demoralizing. The foreman's pay should be in proportion to his ability in the same way as the salary of any other executive, and this means that some means of measuring his success or failure should be devised and followed up religiously.

The method of keeping and figuring the pay of day workers enumerated below is the simplest. It requires only a daily record of the number of hours actually spent at the factory, multiplied by the hourly rate. Work which cannot be charged up directly to the product being manufactured is the only kind which should be paid by the day-work method. The time of day workers and week workers which cannot be charged up directly to the product must be absorbed by a general overhead expense which is prorated to the direct chargeable time.

Piecework

A very common, and, from the employers' standpoint, popular method of payment is that of piecework. Its popu-

larity is due to the ease with which it is understood by the employees and with which it is figured by the pay-roll department. The great objection to piecework is that it has been grossly misused by some employers, who cut the rates whenever they saw that the employees were getting what seemed too much money. Sometimes this rate-cutting was due to setting some piece rates so high that a few employees were able to earn, without effort, such high wages that they threw the entire wage scale of the factory out of balance and caused dissatisfaction among those less fortunate. Invariably a situation of this sort is the result of the piece rates that have been set at a guess. A piece rate, however, set accurately as described in this book, is a reliable method of payment. Nevertheless, piecework is not recommended, because its abuse has associated it in the minds of employees with rate-cutting, so that even its proper use is liable to arouse ill-feeling.

Time Work with Bonus

The method of payment which is most satisfactory is time work with bonus, which may be defined as a method of payment by which the employee is properly compensated for turning out a product of standard quality in standard time, both of which have been scientifically predetermined. Its advantages are that:

1. It puts before the employee a measure of accomplishment.
2. It pays a regular day or week wage on which the employee can depend.
3. In addition it pays the employee a bonus as his share in the profits.
4. It enables the management to locate the cause of low earnings and correct the condition by splitting the work into relatively small units.

5. It provides for the readjustment of wages per hour similar to the readjustment of wages per day, without in any way affecting the time standards.

Under time work with bonus every employee on the operation is paid for each hour he puts in at the factory at a rate which is determined by a number of considerations, such as skill, experience, supply and demand, and so on. This hourly rate is called the "base rate" of the operation. The question of the amount of money per hour, or base rate, is one which should be settled between employer and employee and should not be confused with the amount of time taken to complete a given quantity of work.

If the employee is an experienced workman, as he is supposed to be, he should be able to turn out each hour or day a certain amount of work of a certain quality, the amount of which is determined through job standardization. If he accomplishes this, he is a more valuable workman than one who turns out but half the quantity, and he should, therefore, participate in the savings or the profits made possible through his application to his work and through the quality and quantity which is the result. This share in the earnings which he has helped to make has been termed a bonus.

Figuring the Pay-Roll

The bonus should be expressed in terms of time, just as are all items on the pay-roll, in order to make it easy to figure. If the bonus is a percentage of the standard time it is only necessary for the clerk to add the percentage to the time taken, and then to multiply the total by the base rate.

When an employee is given a job for which the standard time is two hours and the bonus rate is 25 per cent, and he completes it in the standard time (i.e., in two hours), he is paid not only for the two hours taken but, in addition, for 25 per cent of the two hours (i.e., for half an hour). With

a base or hourly rate of 60 cents an hour for every hour put in at the factory, he will receive 60 cents an hour for the two hours actually spent on the work (i.e., \$1.20) *plus* the half-hour of bonus time (i.e., \$.30), making a total pay for the job of \$1.50.

PAY EARNED ON TIME WORK WITH BONUS

	2	hours time taken
25% of 2 hours	½	" bonus earned
	2½	hours total time paid for
	\$ .60	rate per hour
	\$1.50	total pay earned, equivalent to \$.75 per hour.

The Base Rate

The first thing to determine is the base rate of the operation to be considered. It has already been stated that the base rate should be at least the same as the "market rate" of the operation, and that the amount should be subject to the same influence as the day rate.

The usual way of letting the day or base rate adjust itself is, however, the cause of much inequality of pay among the employees. The relative requirements of the operations are not taken properly into consideration in paying for them. It is not at all rare to find in the same factory where two jobs are of exactly the same sort, requiring the same breaking in period and application, and involving the same risk or monotony, that one workman is paid a great deal more than another. Little attention is given such factors as these, except when a job is so difficult or hazardous that the employees refuse to work on it unless they are paid extremely high wages. Even then it is a recognized fact that many jobs which in-

volve the greatest risk to life and limb are notoriously underpaid.

Some of the factors which should have consideration are:

Experience
Application
Monotony
Risk
Physical strain

In individual factories, there may be in addition other factors of as great or even greater importance.

Determining Base Rate by Survey

A survey primarily for the purpose of determining the relative weight of these factors should be made before a detailed analysis is begun. Such a survey may last from a few weeks to a couple of months, depending upon the number of operations in the factory. The data would incidentally be of use in many ways. The employment department, for instance, needs information of a similar nature in hiring employees for various jobs; and the one survey might be made to serve two purposes. The knowledge gained by the survey will in some cases make possible the shortening of the period of job standardization because it will supply preliminary information which will make a direct approach to the studies somewhat easier.

In order to work out this balance between operations it is necessary to tabulate the knowledge gained by the survey. For instance, the operations and the relative rate of the factors might be summarized on one sheet. On the left-hand side of the sheet, the operations should be listed and across the top should be listed the various factors influencing the pay. The relative weight of each factor might be shown by a number. The larger the sum of the numbers for the operation, the larger

should be the pay. This should not be taken to mean, however, that an operation for which the number is twice as large should be paid twice as much as another operation. For greater exactness, it might be possible to weigh the numbers in accordance with the importance of the factor.

Operations, in the first place, divide themselves into two classes: (1) those which are highly specialized,[1] requiring high-grade, trained employees to do the work; (2) those which are unspecialized, and for which it is possible to hire a green hand and break him in after a reasonable period of time.

In considering highly specialized operations it is futile to endeavor to weigh the factors against each other. The pay is reached almost entirely through the relation of supply to demand.

The contrary is true of the unspecialized operations. Some are much easier and more attractive than others, and the aim should be to make the pay in proportion. The commonest factors are risk, monotony, and application, physical strain, and experience.

A few operations in a button factory have been listed in the way they would appear in such a summary. The operations are: (1) tool sharpening, which is highly specialized, (2) freehand sawing, which involves considerable risk, (3) gage sawing, which is the same as hand sawing in almost every respect, except that a mechanical guide materially reduces the risk, and (4) belt sorting, which is a simple operation.

Bonus

The percentage of bonus allowed is also dependent on a number of factors. Once determined, the bonus should never be changed except for a most important consideration. It should be guaranteed in the statement of company policy that

[1] Highly specialized, not in the sense that the division of labor has been carried to its furthest development, but that specialized training is necessary.

neither the standard time rate nor the bonus will be decreased.[2] The analyst must accordingly consider very carefully what would be a just division of the savings.

The amount of saving will be an important factor in this consideration. Every wise manager wants to pay the employees just as much as the operation they are working on can stand. But, again, the particular operation must be considered in its relation to other operations. It might be that on operation 1 some improvement in machinery had increased production 100 per cent; while on operation 2, there was no improvement possible on the machine. If the application required to earn the bonus was practically identical on both operations, it would be manifestly unfair to pay a bonus of 50 per cent on operation 1 while paying a bonus of only 25 per cent on operation 2. If the increase in production on operation 1 was largely the result of the fact that the employees had been loafing on the job previous to analysis, a larger bonus for it than for operation 2 would be even more unfair.

The bonus should be at least 33 1/3 per cent over the standard time with an absolute minimum of 20 per cent. Any amount less will fail to create interest. Thirty-five per cent is a better figure. The amount of bonus paid depends entirely upon the industry and conditions at the particular plant, and no general rule can be laid down to cover it.

Proportion of Base to Bonus

The bonus should *not* be paid in place of wages. Neither should the base rate be less than the usual market rate. If the base rate is low and the bonus paid in place of wages, the employees will not receive a fair wage when they are on day work. This may occur either because they are obliged to do day work if the job has not been studied, or because they are

[2] If the market rate is increased or decreased, it is the base rate which will be raised or lowered: there will be no effect on either the standard time or the bonus rate.

not yet skilled enough to do the job in the standard time. The principle of time work with bonus is to make proper compensation for quality and quantity, and not to penalize low quantity.

A low base with a bonus, part of which is in lieu of wages, is unsatisfactory to the employees. In one factory, for example, the practice of paying a low base rate had been established some years ago, at which time not so much consideration had been given to psychology and the relations between labor and capital. The rates which had been established and the treatment which the employees had received had been most satisfactory. Nevertheless there came a time when they asked the company to reconsider their method of payment. Their suggestion was to have the base rate raised to correspond with the ruling wage paid the general help in the department and to have a correspondingly smaller bonus paid than under the old plan. This left their total wage equal to what they had been receiving, which was perfectly satisfactory to them. In other words, the unit cost of producing was approximately identical under both arrangements. The company was glad to have this plan put into effect immediately. The difference between the two plans can be brought out best by tabulation.

	Old Plan		New Plan
Base rate per week..	$15.00		$21.00
Bonus 100 per cent..	15.00	Bonus 45 per cent	9.45
Total	$30.00		$30.45

Company Policy Statement

The first rates set through job standardization are of great importance in that they mean the determination of the company policy on all rates set throughout the factory. The introduction of time work with bonus marks a change in the company policy; and it is only natural that the amount of base

rate and the bonus on the first operation, the increase over the former wage, and all the details of the way in which it is first introduced should be regarded by them as significant of future policy. It must be kept foremost in mind that if it is found necessary to make any change at a later date such a change will greatly diminish the faith which the employees have had in the company.

Every company should formulate in writing a definite policy as to the principles on which it bases its wage payment, so as to prevent misunderstandings as far as possible. This is most essential before any of the employees are started on any method of payment differing from that under which they were hired and have been working. The fact that time work with bonus is not generally understood by the employees makes it especially necessary to give a full statement of the company policy in all its applications. This statement should include explanation not only of its main features, but also of the way in which allowances are given for abnormal conditions, learning, or group work. It includes in addition the statement of the principle of the guaranteed rate, which consists of a guarantee that for a definite period the employee will receive at least the amount of money he has been earning during the past months, whether he earns the bonus or not. If the principle of setting the base rate at the customary day rate is followed, the guaranteed rate is rarely needed. But there are times when the employees' earnings are so high as to be out of all proportion to the earnings of even some highly trained employees. In such cases where the earnings are out of line, it is advisable to set the base rate at the market rate, instead of at the previous earnings, guaranteeing, however, at least the former amount over a period of, say, three months.

All such questions, which are bound to arise sooner or later, should be covered at the outset. The company policy on time work with bonus should be stated in writing as clearly, com-

pletely, and as definitely as possible, signed by the proper authority, and posted in a conspicuous place in all departments operating under the method.

Standard Form of Statement

The recommended standard form for this statement follows:

Company Policy on Time Work with Bonus

I. Standard Time:

A—"Standard Time" will be set for all the operations of each department.

B—Additional time will be allowed for employees to compensate for any abnormal or unforeseen conditions arising on a job on which a "Standard Time" has been set.

C—Additional time allowance will be given each employee who starts on bonus work under instructions. The amount of additional time and the period over which this time applies will vary with the skill required to do the work, the length of time the employee has been on the operation, and the number of changes in method of operating which are adopted.

D—A bonus will be allowed *only* on the "Standard Time" in which the work should be completed, and not on the extra allowed time.

E—The "Standard Time" allowed on any operation will never be decreased unless improvements are made which change the operation materially.

II. Money Payments:

A—A "Base Rate" or rate per hour will be set for each operation in the department in which Time Work with Bonus is used.

B—The bonus will be a percentage addition to the "Standard Time" provided the *time taken* to do the job is equal to or less than the time *allowed:* otherwise, the employee will be paid at the base rate for the *time taken.*

C—When starting on bonus work any employee who does not earn more than his present rate will be guaranteed this rate for a period of three months. This is called his "Guaranteed Rate."

D—When a bonus worker is required to work for *less than a day* on work of his own class which cannot be put on a bonus, he will be paid the Base Rate for the time actually put in on the work.

E—When a bonus worker is required to work for *a day or longer* on work of his own class which cannot be put on a bonus, and if he has been earning his bonus 75 per cent of his total working hours for the past period, he will be paid on the same basis as the average of his past month's earnings.

F—When a bonus worker is transferred temporarily to a different class of work, he will be paid the Base Rate of his regular work, provided the work is done within the Standard Time, unless he can make more money on bonus at the new job.

G—In case a bonus worker makes a mistake in his work and does not rectify it at the time he does the work, he will not receive his bonus.

H—No bonus worker will be given additional time to correct his mistake.

I—If any work is discovered to be faulty by another department, the amount of bonus paid for the job in which the work is faulty will be deducted from bonus earned and not yet paid.

J—If one member of a group of employees working together on an operation makes a mistake, none of the other employees of the group will earn a bonus on this job.

K—If a new employee is teamed up with experienced employees on group work, extra time will be added to the time allowed to compensate for the inexperience of the new employee.

L—The overseers or foremen will be on a Day Work basis with no bonus payments, as they represent the company and are responsible for the quality and the quantity of the product.

CHAPTER XVII

SUMMARIZING THE STANDARDS AND INSTRUCTIONS

Final Steps in Standardizing

The final steps in "analyzing the studies and setting the standards" consist of: (1) summarizing the standard times into final form so that they may be readily used in determining the amount of time the employee should take to complete a job; and (2) writing instructions for the employees so that they shall have definite information before them as to the manner of doing the job and thus be able to complete it within the standard time. This completes the work of determining the standards and is the last act before the standards can be put into effect. The time required for these steps is considerable, rarely less than half as long as the time of "taking the studies" and sometimes fully as long, if there are many and complex combinations of variables.

Final Form of Standards

The process of summarizing the standards into final form consists of taking the standards determinined for each element or combination of elements and putting them into some record, such as tables or curves. The standards of each element occurring in an operation should, if possible, be expressed in the same unit—area, or linear feet, or weight, so as to simplify computing the time a particular job should take. In some cases certain of the elements in an operation may be dependent upon the weight of the material being operated upon, while other elements in the same operation may be dependent upon

the bulkiness of the material. An experienced analyst, in such a case, should spend considerable time and thought working out some means of expressing the time of the element in a single unit and in this way simplifying the final tables. Although this process takes a great deal of his time it will probably result in simplifying the figuring of the amount of time required for a job so that this work can be done by a clerk rather than by a more highly paid, practical workman, who at first had been necessary. The standard times, or the time allowance, under various conditions and requirements should then be condensed and expressed in a form which is as simple as possible.

Instruction Cards for Operations

The instructions for employees cover the standard method of performance. A comprehensive knowledge of the operation is, of course, necessary for the successful maintenance of standards. The instruction cards give all the information which bears on the operation with reference to the machines, tools, equipment, and material.

This portion of the card is essential because some employees may understand the operation imperfectly and others may, perhaps, have been incorrectly taught. The instructions also describe the quality standard and the standards for each condition, if there is more than one.

When quality standards cannot be expressed in words they should be illustrated by having exhibits of the product near the machines or in the department so that they may be readily accessible to the workmen, but so placed that they cannot be taken away, lost, or exchanged. Although certain classes of products may have a general quality standard, often each product of a class has a special quality of its own. This variation is due to different factors, such as the purpose for which the article is to be used, or the "fussiness" of the customer.

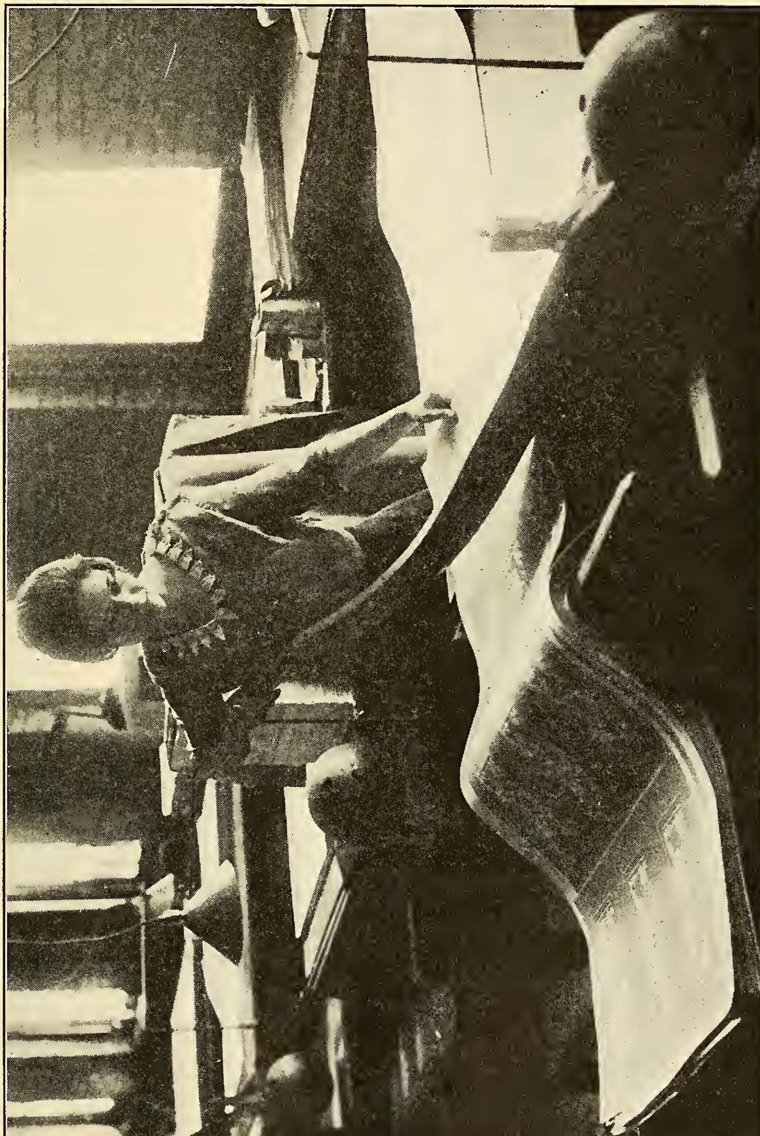


Figure 38. Process of Hand-Cutting Lithographed Sheets

Where such a condition exists special quality standards should accompany the order to guide the employees properly in their work. These special quality standards should be preserved upon completion of the work as they will serve as a record, in case of complaint by the customer upon receipt of goods, or in case the customer desires more goods of the same quality.

The detailed instructions and the quality standards are not only essential to the employee but serve also another purpose, namely, as a guide to the instructor and to the inspector as well. Only in this way is it possible for all parties concerned to work together properly and to produce a satisfactory product economically.

Summarization of Squaring Paper

Perhaps the best way of showing how the data for squaring lithographed sheets of paper were summarized and simplified is to take some of the actual operations and follow their development, step by step, from beginning to end. For the purposes of illustrating the standardization of these different operations twelve figures are used. These illustrations embrace Figures 38 to 49 inclusive.

Figure 38 is a photograph of the process of cutting. The knife used for the purpose is operated, at one end, by hand; at the other end it is held in place by a pivot. Although the work is simple, the operation demands care and accuracy. The employee has either to trim off an edge of the paper or else to split the sheet into several pieces.

These sheets vary in size from 5 inches by 10 inches, to 30 inches by 40 inches; the average size, however, is approximately 22 inches by 30 inches. The weight of the paper—or, as it is more commonly called, the weight of the stock—varies from 45 pounds for 500 sheets, 12 inches by 20 inches, to 300 pounds for the same number of sheets 24 inches by 36

Time *9.40* to *9.50* | Study No. or Symbol *4* | File *CUG*

Observer *W.E. Stevens* | Date *Oct. 18, 1916*

Operation *Hand Cutting* | Checked by *E.P.S.*

Department *Finishing*

Location *HCI*

Employee *#714* Rate *35¢/hr.*

Implements

Materials

Conditions and Remarks

Stock-6 ply blank
Size sheet 12¾"x 20"

Cut 20"

	g			c			d			y		
0.02	0.04	0.08	0.07	0.06	0.09							
0.03	0.02	0.02	0.06	0.07	0.07							
0.03	0.02	0.03	0.07	0.06	0.08							
0.06	0.03	0.02	0.07	0.07	0.07							
0.03	0.01	0.02	0.07	0.08	0.07			0.02			0.08	
0.03	0.03	0.02	0.06	0.05	0.04							
0.03	0.05	0.02	0.06	0.11	0.05	0.04			0.07			
0.02	0.04	0.03	0.05	0.07	0.05							
0.02	0.03	0.02	0.09	0.07	0.04						0.04	
0.03	0.02	0.04	0.06	0.08	0.08							
0.02	0.02	0.02	0.06	0.06	0.08		0.04					
0.03	0.03	0.03	0.07	0.05	0.06							
0.03	0.03	0.02	0.07	0.05	0.05			0.03			0.07	
0.03	0.03	0.02	0.06	0.05	0.05							
0.03	0.03	0.02	0.06	0.06	0.09							
0.02	0.03	0.03	0.07	0.06	0.09							
0.02	0.02	0.03	0.07	0.06	0.10	0.03			0.22			0.07
0.02	0.03	0.02	0.08	0.07	0.07		0.04			0.07		
0.03	0.02	0.05	0.05	0.05	0.12							
0.03	0.02	0.02	0.11	0.04	0.07							
0.02	0.03		0.06	0.08								
0.02	0.02		0.09	0.06								
0.02	0.03	0.02	0.07	0.06	0.069			0.003			0.008	
0.04	0.01		0.07	0.11								
0.03	0.02		0.08	0.07		0.04						
0.02	0.03		0.03	0.07								

Detail Elements *per sheet*	Av. Time
a	
b	
(2) c *Cut Sheets*	0.069
(3) d *Set sheets down-per sheet*	0.003
e	
f	
(1) g *Reach for Sheets*	0.026
h	
i	
(4) j *Jog Sheets*	
k	
l	
m	
n	
o	
p	
q	
r	
s	
t *Count Sheets*	
u	
v	
w	
x	
y *Necessary Delays*	0.008

Sy	Read	Ex	Notes	Sy	Read	Ex	Notes	Sy	Read	Ex	Notes
	0.00			g	3.78	0.03		g	7.05	0.03	
g	0.02	0.02		c	.83	0.05		c	.11	0.06	
c	.09	0.07		g	.86	0.03		g	.13	0.02	
g	.12	0.03		c	.97	0.11		c	.18	0.05	
c	.18	0.06		g	4.01	0.04		d	.21	0.03	
g	.21	0.03		c	.08	0.07		y	.28	0.07	
c	.28	0.07		g	.11	0.03		g	.30	0.02	
g	.34	0.06		c	.18	0.07		c	.35	0.05	
c	.41	0.07		g	.20	0.02		g	.37	0.02	
g	.44	0.03		c	.28	0.08		c	.46	0.09	
c	.51	0.07		g	.30	0.02		g	.49	0.03	
g	.54	0.03		c	.36	0.06		c	.58	0.09	
c	.60	0.06		d	.40	0.04		g	.61	0.03	
g	.63	0.03		g	.43	0.03		c	.71	0.10	
c	.69	0.06		c	.48	0.05		g	.73	0.02	
d	.73	0.04		g	.51	0.03		c	.80	0.07	
y	.80	0.07		c	.56	0.05		g	.83	0.03	
g	.82	0.02		g	.59	0.03		c	.95	0.12	
c	.87	0.05		c	.64	0.05		g	.97	0.02	
g	.89	0.02		g	.67	0.03		c	8.04	0.07	
c	.98	0.09		c	.73	0.06					
g	1.01	0.03		g	.76	0.03					
c	.07	0.06		c	.82	0.06					
g	.09	0.02		g	.84	0.02					
c	.15	0.06		c	.90	0.06					
g	.18	0.03		g	.93	0.03					
c	.25	0.07		c	5.00	0.07					
g	.28	0.03		d	.04	0.04					
c	.35	0.07		y	.11	0.07					
g	.38	0.03		g	.13	0.02					
c	.44	0.06		c	.18	0.05					
g	.47	0.03		g	.20	0.02					
c	.53	0.06		c	.24	0.04					
g	.55	0.02		g	.27	0.03					
c	.62	0.07		c	.35	0.08					
g	.64	0.02		g	.37	0.02					
c	.71	0.07		c	.43	0.06					
d	.74	0.03		g	.46	0.03					
j	.81	0.07		c	.52	0.06					
y	2.03	0.22		g	.53	0.01					
g	.05	0.02		c	.64	0.11					
c	.13	0.08		g	.66	0.02					
g	.16	0.03		c	.73	0.07					
c	.21	0.05		g	.76	0.03					
g	.24	0.03		c	.83	0.07					
c	.35	0.11		g	.91	0.08					
g	.37	0.02		c	6.00	0.09					
c	.43	0.06		g	.02	0.02					
g	.45	0.02		c	.09	0.07					
c	.54	0.09		g	.12	0.03					
g	.56	0.02		c	.20	0.08					
c	.63	0.07		g	.22	0.02					
g	.67	0.04		c	.29	0.07					
c	.74	0.07		g	.31	0.02					
g	.77	0.03		c	.38	0.07					
c	.85	0.08		d	.40	0.02					
d	.89	0.04		y	.48	0.08					
Ans	3.19		Phone	g	.50	0.02					
g	.21	0.02		c	.54	0.04					
c	.29	0.08		g	.56	0.02					
g	.33	0.04		c	.61	0.05					
c	.39	0.06		g	.64	0.03					
g	.41	0.02		c	.70	0.06					
c	.48	0.07		g	.72	0.02					
g	.50	0.02		c	.76	0.04					
c	.56	0.06		y	.80	0.04					
g	.59	0.03		g	.84	0.04					
c	.66	0.07		c	.92	0.08					
g	.67	0.01		g	.94	0.02					
c	.75	0.08		c	7.02	0.08					

OVER ALL

Sy	Read	Ex	No.
	0.00		
g&c	1.01	1.01	12
d	1.05	0.04	
y	.24	0.19	
g&c	2.31	1.07	10
d	.35	0.04	
y	.40	0.05	
g&c	3.45	1.05	12
d	.48	0.03	
g&c	4.46	0.98	11
d	.50	0.04	
g&c	5.52	1.02	10
d	.56	0.04	
y	.62	0.06	
g&c	6.13	0.51	5
y	.20	0.07	
g&c	7.23	1.03	11
d	.28	0.05	
y	.30	0.02	
g&c	8.38	1.08	12
d	.41	0.03	
y	.45	0.04	
g&c	9.26	0.80	9
d	.29	0.04	
y	.34	0.05	

g&c	d	y	No
1.01	0.04	0.19	12
1.07	0.04	0.05	10
1.05	0.03		12
0.98	0.04		11
1.02	0.04	0.06	10
0.51		0.07	5
1.03	0.05	0.02	11
1.08	0.03	0.04	12
0.80	0.04	0.05	9
0.093	0.003	0.005	

OVER ALL

g & c	Set sheet and cut	0.093
d	Set sheets down	0.003
y	Necessary Delays	0.005
		0.101

Figure 39. Time-Study Sheet Showing Elements Involved in Operation of Splitting Lithographed Sheets

Hand-cutting
Tabulation of Detail Time Studies

Note sheet number....	$10/9^1/21$	$10/9^2/21$	$10/9^3/21$	$10/9^4/21$	$10/9^5/21$	$10/10^1/21$	$10/10^2/21$	$10/11^1/21$	$10/11^2/21$	$10/11^3/21$	$10/18^1/21$	$10/18^2/21$
Description..........	Trimming edge of sheet	Trimming edge of sheet	Trimming edge of sheet	Splitting sheet	Splitting sheet	Trimming edge of sheet	Trimming edge of sheet	Splitting sheet	Splitting sheet	Trimming edge of sheet	Trimming edge of sheet	Splitting sheet
Order number........	1,006	1,006	1,010	1,010	1,006	1,006	1,006	1,057	1,057	1,057	1,036	1,036
Weight of stock......	22x28–50	22x28–50	24x36–190	24x36–190	22x28–50	22x28–50	22x28–50	22x28–50	22x28–50	22x28–50	6-ply	6-ply
Size of sheet..........	11¾x 23¼	22¼x 23½	16½x 24¼	16½x 24¼	6¾x 23	6¾x 11½	6⅝x 11⅜	17¾x 23¾	11⅞x 17¾	11⅞x 17¾	12¾x 20	20x 25
Length of cut........	23¼	23½	24¼	24¼	6¾	11½	11⅜	17¾	11⅞	11⅞	20	20
Employee's number...	714	711	712	712	713	711	714	712	712	712	714	714
Times in per 1,000 Sheets												
g –Reach for sheet....	34.0	43.9	34.8	35.4	28.1	34.6	41.3	36.7	27.5	25.2	26.8	32.2
c –Cut sheet..........	75.3	79.0	70.0	74.2	49.6	84.4	96.0	80.7	72.6	62.0	69.0	64.0
d –Set sheets down—per cut...........	3.8	3.8	5.6	4.8	0.6	2.0	2.8	1.7	3.9	1.7	4.0	3.3
y –Necessary lost time—per cut..........	6.2	4.8	5.6	7.8	2.2	10.0	5.2	3.8	7.5	3.8	7.6	7.8
j –Job sheets remaining in hand—per cut					2.3			4.0				
j′ –Jog sheets that have dropped to right side of knife—per cut..					4.5			$\left.\right\}$ 2.7	2.9 $\left\{\right.$			3.4
d′–Set sheets down after j′................					0.5							0.9
Over-all Times												
g+c–Reach and cut..	111.3	115.0	103.9	114.0	86.7	120.5	112.5	122.0	96.5	91.6	93.0	103.0
d –Set sheets down—per cut...........	3.8	3.8	5.6	4.8	0.6	2.0	2.8	1.7	3.9	1.7	3.4	3.4
y –Necessary lost time—per cut..........	6.2	4.8	5.6	7.8	2.2	10.0	5.8	3.8	7.5	3.8	5.2	7.0

Figure 40. Tabulation Sheet Showing Results of a Number of Time Studies

inches. The average weight, however, is 65 pounds for 500 sheets, 22 inches by 30 inches.

The elements, and their explanatory symbols, entering into the operation of squaring are:

g. Reach for sheets
c. Cut sheets
d. Set down sheets
j. Jog sheets that remain in hand
j′. Jog sheets that have fallen to the right of the knife
d′. Set down sheets after having completed operation j′
y. Necessary lost time
t. Count sheets

Figure 39 which gives a detailed time study of the elements just enumerated, gives also other factors entering directly into

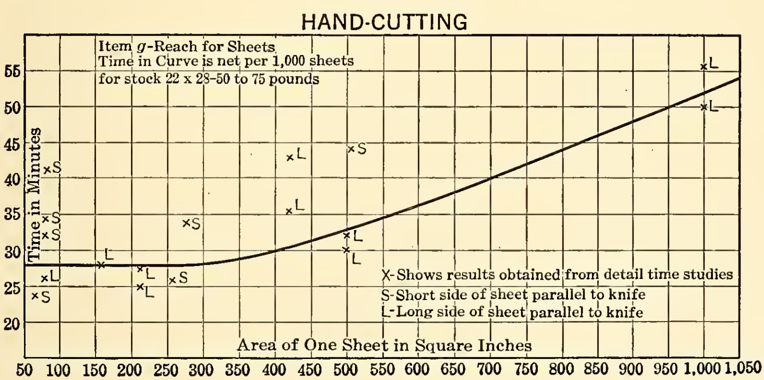


Figure 41. Graphic Chart Showing Amount of Time Necessary to Reach for a Sheet of Lithographed Paper

the operation. These factors which are called variables (see Chapter XIII) are enumerated in the upper left-hand corner of the time-study sheet. They are: The weight of the stock; the size of the sheet; the length of the cut; and the clock number of the employee. This last item is used to determine the effect of the personal equation upon the operation. Further-

more, the weight of the stock is also at times a variable; but in this particular operation it is a constant up to 75 pounds; any weight in excess of that amount would make it a variable.

For the purposes of comparison the results of a number of time studies are tabulated in Figure 40.

After tabulating these results it is possible to plot the average time for each of the elements according to the variables

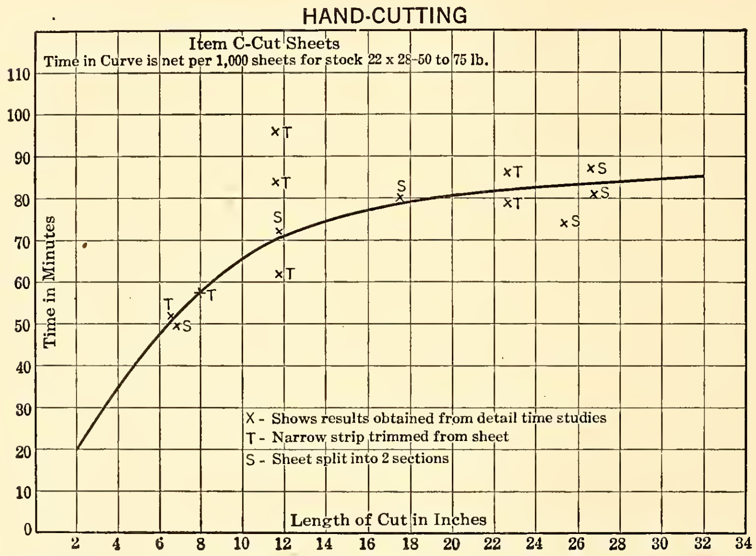


Figure 42. Graphic Chart Showing the Element of Cutting Lithographed Sheets

which are: the size of the sheet and the length of the cut. Figure 41 represents item g, reach for the sheet; the variable in this case is the size of the sheet. Figure 42 represents item c, cut sheets; here the variable is the length of the cut in inches. Figure 43 represents item d, set down sheets; the variable is the size of the sheet. Figure 44 is item y, necessary lost time; the variable is the size of the sheet.

It follows then, that all the elements in the operation which are plotted on the basis of the same variable together with the constants for these items can be collated, as in Figure 45.

HAND-CUTTING

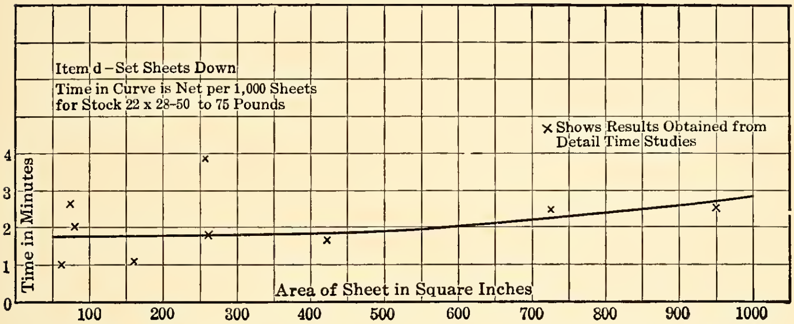


Figure 43. Graphic Chart Showing the Element of Cutting Down Sheets

After being collated, these elements may be reduced to one curve such as Figure 46. This curve represents a summariza-

HAND-CUTTING

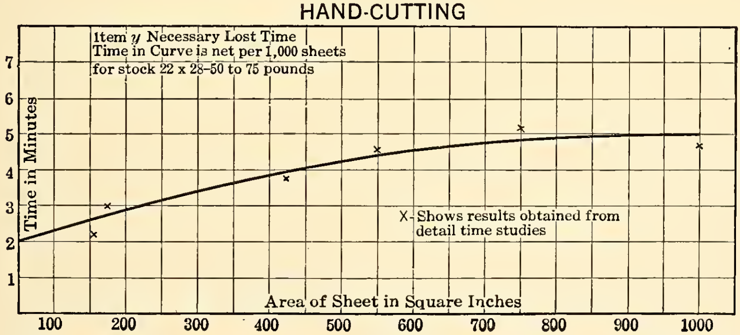


Figure 44. Graphic Chart Showing Necessary Lost Time in Cutting Lithographed Sheets

tion of the time taken to cut 1,000 sheets of paper 22 inches by 28 inches, from stock varying from 50 to 75 pounds for a ream of 500 sheets.

HAND-CUTTING

22 x 28—50 to 75-Pounds Stock

Collate Values for Items g—d—y—j—j′—d′—t into One Curve

Area of Sheet	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	950	1000
Item:																				
g............	28.0	28.0	28.0	28.0	28.0	28.0	29.0	30.0	31.5	33.0	35.0	37.0	38.5	40.0	42.0	44.0	46.0	48.0	50.0	52.0
d............	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.8	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.9
y............	2.0	2.3	2.6	2.9	3.2	3.5	3.7	3.9	4.1	4.3	4.5	4.6	4.7	4.8	4.9	5.0	5.0	5.0	5.0	5.0
j—j′—d′—t....	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5
Total...........	37.2	37.5	37.8	38 1	38.4	38.7	39.9	41.1	42.9	44.6	46.9	49.1	50.8	52.5	54.7	56.9	59.0	61.1	63.2	65.4

Figure 45. Tabulation Showing All Elements Plotted on a Uniform Basis

Figure 42 is the only chart which has the length of cut in inches as its variable. Hence Figure 42 and Figure 46 contain all the information that is necessary to set rates on hand-cutting stock of the size and weight mentioned in the preceding paragraph.

From these two charts, accordingly, a table of standard times (Figure 47), was drawn up for the rate-setter. In drawing up this table an allowance of 10 per cent was determined as the time necessary to allow for the necessities of life and for fatigue.

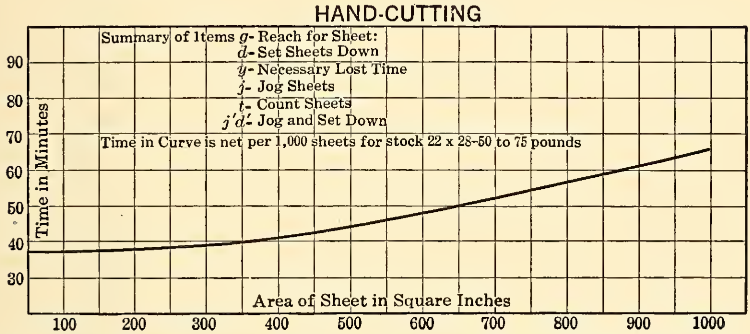


Figure 46. Summarization of All the Elements Having Uniform Basis by Area of Sheet

The instructions, which made clear to the rate-setter the way in which to use the chart of standard times, were given in the form of an example, Figure 48. The instructions include the method of figuring the time necessary to do a typical job. From the tabulation sheets on which the detail times taken from the time studies were recorded, sample sheet shown in Figure 40, it was also possible to determine the different percentages of time which had to be allowed in handling weights of stock that weighed more than seventy-five pounds to the ream. These percentages are shown in table Figure 49.

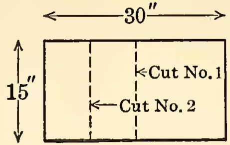
Standard Times

Average Net Time Plus Allowances			
Items g + d + y + j + t + j′ + d′		Item C	
Area of Sheet in Sq. Inches	Time per 1000 Sheets in Minutes	Length of Cut Inches	Time per 1000 Cuts in Minutes
50	41.0	3	22.0
100	41.3	3	29.8
150	41.5	4	37.4
200	41.9	5	45.0
250	42.2	6	53.0
300	42.5	7	58.4
350	43.9	8	64.0
400	45.2	9	69.5
450	47.1	10	73.8
500	49.0	11	77.0
550	51.5	12	79.4
600	54.0	13	81.5
650	56.0	14	82.5
700	57.7	15	83.7
750	60.2	16	84.8
800	62.5	17	85.8
850	65.0	18	87.0
900	67.2	19	88.1
950	69.5	20	88.6
1,000	72.0	21	89.2
1,050	74.2	22	90.2
1,100	76.4	23	90.9
1,150	78.6	24	91.5
1,200	80.8	25	92.0
1,250	83.0	26	92.5
1,300	85.2	27	93.0
1,350	87.4	28	93.5
1,400	89.6	29	94.0
1,450	91.8	30	94.5
1,500	94.0	31	95.0
1,550	96.2	32	95.5
1,600	98.4	33	96.0
1,650	100.6	34	96.5
1,700	102.8	35	97.0
1,750	105.0	36	97.5

Figure 47. Table of Standard Times Taken from Figures 42 and 46 to Be Used by the Rate-Setter

(a) Above time is for 22 x 28 in 50 pounds to 75 pounds stock
(b) Base rate is 20¢ per hour
(c) Bonus time is 35% of task time

Example of method of figuring standard time per lot of 1,000 sheets to be cut as per diagram



Weight of stock 22 x 28-60 lb.

CUT NO. 1:

Area of sheet 450 sq. in.	Handling time - g + d + x + j + t + j′ + d′	47.1
Length of cut 15 inches	Cutting time-c	83.7
	Standard time per 1,000 sheets	130.8

CUT NO. 2:

Area of sheet 225 sq. in.	Handling time - g + d + x + j + t + j′ + d′	42.1
Length of cut 15 inches	Cutting time-c	83.7
	Standard time per 1,000 sheets	125.8

Cut No. 1: Standard time per 1,000 sheets 130.8
Cut No. 2: " " " " " 125.8
Cut No. 1 & 2: " " " " " .... 256.6 minutes or 4.28 hours

Figure 48. Instructions to the Rate-Setter in the Form of an Example

Summarization of Laying Cloth

In the summarization of laying cloth (see Chapter X Figure 22) some of the data that appeared in squaring lithographed sheets of paper is not used. For instance, the time-study sheet is omitted.

The operation is also quite different from the one previously discussed, for it is accomplished by two people, here called

HAND-CUTTING

Additional Time Allowance for Stock Heavier than 22 x 28—50 Pounds to 75 Pounds

Stock 22 x 28— 75 pounds to 100 pounds	add	5%	to Standard	Time
" " "—100 " " 175 "	"	10%	" "	"
" " "—175 " " 200 "	"	12%	" "	"
4 Ply Stock 22 x 28—188 pounds	"	12%	" "	"
5 " " " "—212 "	"	19%	" "	"
6 " " " "—254 "	"	26%	" "	"
8 " " " "—312 "	"	33%	" "	"
10 " " " "—360 "	"	40%	" "	"

Figure 49. Showing Tabulation of Additional Time Allowance for Stock Heavier than 75 Pounds

A and B. Figure 50 shows that at times the two men work independently and at times in unison. To illustrate, man A performs two of the "starting elements" alone, while man B performs three. After that they perform a number of elements together. They then separate, man A taking care of some elements and man B taking care of others. In completing the final elements they work together. Figure 50 is arranged in columns so that the differentiation of the workmen's duties is clear.

The same figure also shows the unit times for the constant elements of the operation. (For the method of determining constant elements see Chapter XIII.) There are four items, however, against which no figures appear, and these are

Man A — Starting Elements (Per Lay) — Man B

Man A	Time In Decimals of Hours	Man B	Time In Decimals of Hours
Obtain route slip	0.013	Move tools, sketches, etc.	0.009
Examine route slip	0.004	Clean table	0.007
		Remove ticket, first piece	0.001

Lay first layer (included in laying elements)	
Obtain sketch	0.002
Unroll sketch	0.003
Adjust sketch—first time	0.006
Mark first end	0.003
Mark table	0.001
Obtain shears	0.001
Cut first end	0.001
Walk to 2nd end (allowance)	0.001
Mark 2nd end	0.002
Mark table	0.001
Obtain shears	0.001
Cut 2nd end	0.001
Roll up and remove sketch	0.006

Laying Elements (Per Layer)

Pull cloth	(variable)
Straighten 1st section	"
Straighten and even......feet	"
Walk......feet	"
Obtain shears	0.001
Cut	0.001

Cloth Elements (Per Piece)

Roll up cloth	0.003	Roll up cloth	0.003
Mark route slip	0.002	Tie ticket	0.002
Obtain cloth	0.004	Remove cloth	0.001
Heave pole	0.001	Help obtain cloth	0.003
Feel nap	0.001	Heave pole	0.001
		Remove ticket	0.001

Finishing Elements (Per Lay)

Roll up cloth	0.003	Roll up cloth	0.003
Mark route slip	0.002	Tie ticket	0.002
Add entire lay	0.004	Obtain sketch	0.004

Unroll sketch	0.003
Adjust sketch 2nd time	0.009
Obtain pins	0.003
Scatter pins	0.002
Pins............pins at............per pin	(variable)
Remove excess pins	0.002

Figure 50. Combination Instruction Card and Computation Sheet of Operations Used in Laying Cloth

the variables, viz., pulling cloth, straightening first section, straightening and evening, and walking. These variables were more difficult to summarize briefly (see Chapter XII). For example, one of the variables in this operation was the nature —or texture—of the cloth. On all figures this changing factor is represented by the symbols G, H, J, and K, which were arbitrarily chosen to represent different textures.

The operation of laying cloth, as described on the instruction card furnished to the workmen is as follows:

1. Man A should pull the cloth with little or no gathering, while man B should guide it at the starting point and start to walk.

2. Man A should remove the weight, while man B finishes walking.

3. Both men should lay the end of the cloth and place the weight, then they should straighten the required number of lengths.

4. They should then work toward the weight until they reach the furthest place which must be evened or straightened, without going far enough to remove the weight.

5. From this point they even and walk back to the starting point and cut the cloth.

Note. In case the cloth is very soft and loose, the men should alternate the straightenings and the evenings until they reach the starting end of the lay, and then should cut the cloth. This note, at the conclusion of the instruction card, shows the possible effect of the variable previously described.

Figure 51 represents the operation of pulling cloth. The time necessary to pull *all* textures of cloth a given number of feet was identical, hence one curve was sufficient to express the operation.

Another variable, as previously noted, was the nature, or texture, of the cloth. We have seen that the time taken in the pulling of cloth, whatever its texture, was the same, but the

time required for straightening and evening the first section varied with the consistency of the fabric. It is, however, im-

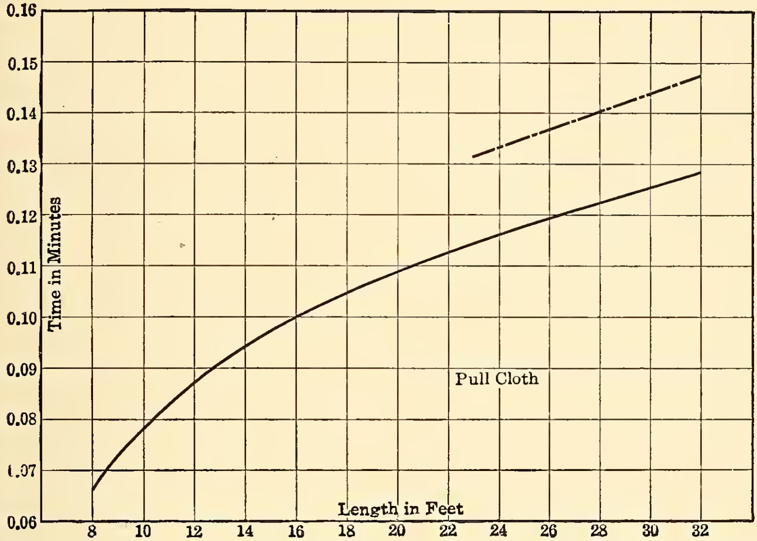


Figure 51. Graphic Chart Showing Time Necessary to Pull a Given Number of Feet of Cloth

possible to make a graphic chart of the nature of the cloth, hence the times taken to perform this operation are taken from a tabulation sheet not included here as in Figure 52.

Straighten First Section of Cloth

	Class of Cloth			
	G	H	J	K
Time in Minutes..........	0.188	0.176	0.164	0.151

Figure 52. Showing Times Taken to Straighten Section of Cloth

In Figure 53 the time required for straightening and evening all textures of cloth is shown. The lines in this chart are

broken so that there shall be no confusion in the mind of the workman as to the number of times any texture of cloth shall

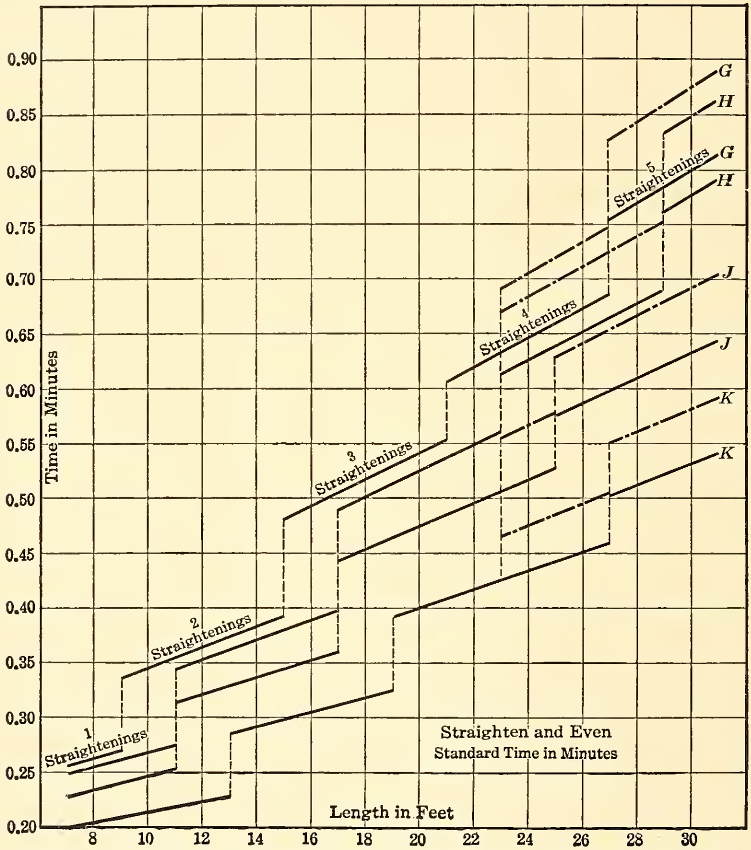


Figure 53. Graphic Chart Showing Operation of Straightening and Evening Cloth

be straightened and evened. For example, K texture may be straightened and evened once when laying from 7 to 13 feet; the same texture may be straightened and evened twice when laying from 13 to 19 feet, and so forth. The dot and dash

line is used here, as in Figure 51, to show the extra time required to perform the operation because of posts or floor col-

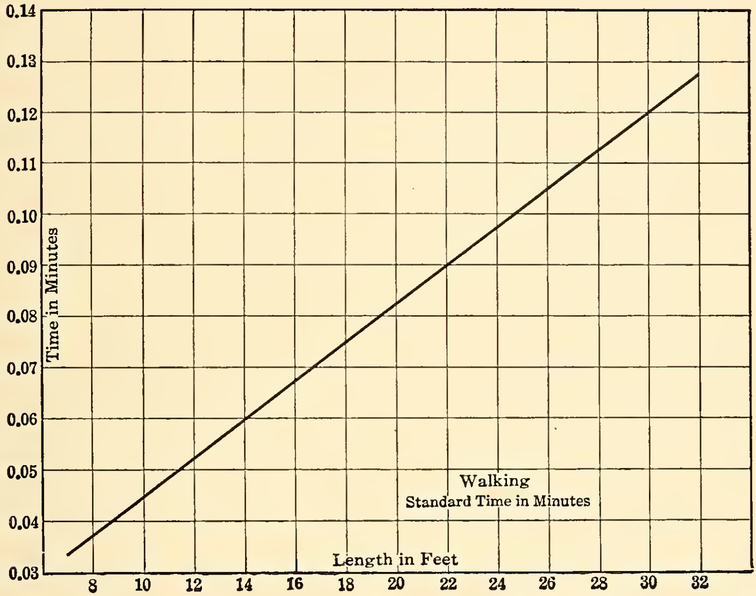


Figure 54. Graphic Chart Showing Time Taken to Walk in Operation of Laying Cloth

umns by which some of the tables ran, and around which the workmen were compelled to walk.

Figure 54 represents the operation of walking. In this case the texture of the cloth had no influence upon the operation, hence one curve was sufficient to express it.

In the summation of the constants and the curves which appear in Figure 55, the readings are transposed into decimals of hours to make them correspond to the decimal divisions which appear on the dials of the clock in the shop.

After the summation has been made, instructions are drawn up so that the various delays that occur in an operation may

Summation of Laying Operations

	Classes of Cloth by Length of Lay in Feet											
	8	10	12	14	16	18	20	22	24	26	28	30
G Class												
Pull	.066	.078	.087	.094	.100	.105	.109	.113	.133	.137	.140	.144
Straight 1st sec	.188	.188	.188	.188	.188	.188	.188	.188	.188	.188	.188	.188
Straight, & even	.263	.345	.364	.383	.493	.518	.542	.620	.705	.732	.841	.875
Walk	.037	.045	.052	.060	.067	.075	.083	.090	.098	.105	.113	.120
Obtain shears	.039	.039	.039	.039	.039	.039	.039	.039	.039	.039	.039	.039
Cut	.074	.074	.074	.074	.074	.074	.074	.074	.074	.074	.074	.074
Remove pole all											.145	.145
Total	.667	.769	.804	.838	.961	.999	1.035	1.124	1.237	1.275	1.540	1.585
Hours	.0111	.0128	.0134	.0140	.0160	.0167	.0173	.0187	.0206	.0213	.0257	.0264
H Class												
Pull	.066	.078	.087	.094	.100	.105	.109	.113	.133	.137	.140	.144
Straight, 1st sec	.176	.176	.176	.176	.176	.176	.176	.176	.176	.176	.176	.176
Straight, & even	.255	.270	.353	.370	.389	.500	.525	.548	.684	.712	.740	.848
Walk	.037	.045	.052	.060	.067	.075	.083	.090	.098	.105	.113	.120
Obtain shears	.039	.039	.039	.039	.039	.039	.039	.039	.039	.039	.039	.039
Cut	.074	.074	.074	.074	.074	.074	.074	.074	.074	.074	.074	.074
Remove pole all											.145	.145
Total	.647	.682	.781	.813	.845	.969	1.006	1.040	1.204	1.243	1.427	1.546
Hours	.0108	.0114	.0130	.0136	.0141	.0162	.0168	.0173	.0201	.0207	.0238	.0258
J Class												
Pull	.066	.078	.087	.094	.100	.105	.109	.113	.133	.137	.140	.144
Straight, 1st sec	.164	.164	.164	.164	.164	.164	.164	.164	.164	.164	.164	.164
Straight, & even	.234	.246	.320	.337	.352	.454	.475	.496	.566	.640	.666	.690
Walk	.037	.045	.052	.060	.067	.075	.083	.090	.098	.105	.113	.120
Obtain Shears	.039	.039	.039	.039	.039	.039	.039	.039	.039	.039	.039	.039
Cut	.074	.074	.074	.074	.074	.074	.074	.074	.074	.074	.074	.074
Remove pole all											.145	.145
Total	.614	.646	.736	.768	.796	.911	.944	.976	1.074	1.159	1.341	1.376
Hours	.0102	.0108	.0123	.0128	.0133	.0152	.0157	.0163	.0179	.0193	.0224	.0229
K Class												
Pull	.066	.078	.087	.094	.100	.105	.109	.113	.133	.137	.140	.144
Straight, 1st sec	.151	.151	.151	.151	.151	.151	.151	.151	.151	.151	.151	.151
Straight, & even	.203	.213	.220	.290	.305	.319	.400	.417	.475	.495	.560	.583
Walk	.037	.045	.052	.060	.067	.075	.083	.090	.098	.105	.113	.120
Obtain shears	.039	.039	.039	.039	.039	.039	.039	.039	.039	.039	.039	.039
Cut	.074	.074	.074	.074	.074	.074	.074	.074	.074	.074	.074	.074
Remove pole all											.145	.145
Total	.570	.600	.623	.708	.736	.763	.856	.884	.970	1.001	1.222	1.256
Hours	.0095	.0100	.0104	.0118	.0123	.0127	.0143	.0147	.0161	.0167	.0204	.0209

Figure 55. Chart Showing Summation of Laying Cloth including Constants and Variables

be systematically cared for. In this case they were arranged as follows:

Method of Handling Delays and Damages

I. Delays

1. Time for short unavoidable delays will be included in the Standard time. Such delays are as follows:— Pole falls, rip selvage, try sketch for narrow cloth, etc.
2. Extra time will be allowed for long unavoidable delays in the following cases:

(a) Change to new piece of cloth . .	.06	hours
(b) Splice piece	.11	"
(c) Shift and relay layer . . .	.03	"
(d) For each damage marked . .	.02	"

The foreman will indicate the nature of each of these delays on the time ticket, but the time will be figured afterwards by the rate-setter.

3. Time taken waiting for foreman, getting his decision, waiting for cloth, etc., will be allowed by foreman according to each individual case.
4. The men will not be allowed to make any change involving the use of more cloth or a piece not specified on the route slip without obtaining the foreman's permission.

II. Damages

1. A layer must mark any serious damage which could injure the garment in some part no matter whether it falls in such a part or not. If any class of damage is marked by the sponger which could be passed in all parts of the garment, the inspector is to notify the superintendent who will order the sponger to cease marking such class of damages.
2. Serious damages must be completely marked when they are discovered, as follows: The location and piece number of the damage must first be written on the paper marker, and then a tape must be placed from the damage to the edge of the lay.
3. If a serious damage falls in a part of $\frac{3}{8}$ or more yards which would have to be recut, and the layer cannot im-

prove its position by shifting or turning cloth, he must get foreman's O K on that part of the paper marker where the damage is indicated.

4. When inspector O K's lay he will count the damages which appear on the marker and those avoided by shifting them outside of the lay and enter the total on the time ticket.

Formula Method for Calculating Standard Times

It is usually practicable to put the final data into comparatively simple form and tabulate it so the time any job should take may be figured regularly even by a rate-setter who may not be versed in the technique of the business. In operations, however, which have a great many variables it is not always practicable to develop the final data into this simplified form. In this case a formula can be developed for figuring the standard time corresponding to various conditions by substituting actual time values as determined by job standardization for the terms in the formula. The formula method has been developed and used for outside constructive work where conditions vary appreciably.

An example of this kind is the laying of brick in a wall. In an ordinary wall the analysis is not difficult, but even here a formula such as is cited below is convenient to use because of the variation of time due to the position and frequency of openings for windows and doors. In complicated work, such as in the laying of brick veneer or facing for structural steel columns, the problem is much more involved because each size, type, and shape of column must have a different arrangement of bricks.

Even in an ordinary wall each layer of brick must be laid so that the vertical joints in one course or layer do not come directly over the joints of the course below, and, correspondingly, the vertical joints of every eighth course or row in this face brick must be tied in with the backing brick immediately behind it so as to make the brick-work a solid unit.

For laying brick to line in an ordinary wall the formula will be:

$$N\left(\frac{J}{M} + \frac{L}{C} + S + \frac{T}{C} + \frac{2H - (S + F)}{8}\right)$$

In this formula the various letters have the following meaning:

N = total number of bricks laid to line; J = time changing jobs; M = number of brick in the section of wall; L = time stretching line; C = number of brick in the course; S = time laying one stretcher to line; T = time jointing; H = time laying one header to line; and F = time laying one filling brick.

The above operation expressed in words means that the total time of laying a course of stretchers to line consists of the sum of the time lost changing jobs, time stretching line, the time actually laying the brick, the time jointing and the extra time laying the header bricks every eighth course. In the latter term we find 2 headers (2H) replacing a stretcher, S, and a filler, F, and as these header corners are assumed to occur every eighth course the time is divided by 8.

It will be seen how readily changes can be made to provide for differences in design of wall. For example, if the header course occurs once in 6 courses instead of 8, the figure 6 can be substituted for 8. If a different type of header course is used, the change also can be readily made. Similarly the formula can be extended to include the backing brick and the fillers for any type of wall. Formulas can be worked up to apply to other classes of brick work such as veneer for pilasters, projecting courses, mouldings, flat and circular arches, cornices, and so forth.

Where the bricks are to serve as a veneer for a structural steel column, moreover, it is necessary to figure how many

corner bricks are to be laid, since they are the hardest to lay; then how many bricks are to be cut and in what way, and how to use up the "bats" or small pieces of brick which are cut off. Thus for a particular pilaster enclosing a steel column the formula for the face brick per course would be as follows:

$$5\frac{J}{M} + 2C + 1\tfrac{1}{2}N\frac{5}{6} + R + H'\frac{1}{6} + 2C'\frac{1}{6} + 3V + 4T$$

The time values corresponding to the letters in the formula can be taken from a tabulation worked up from time-study data similar to that shown in the following table:

LINE	FACE SELECTED	BACKING BRICK
	Time per Brick	Time per Brick
Changing jobs	0.03	0.03
Stretching line	0.05	0.04
Jointing	0.14	0.06
Brushing	0.01	0.01
Stretcher laid to line	0.40	0.27
Stretcher to complete course	0.69	0.47
Stretcher cut to complete course	1.12	0.65
Stretcher cut special	1.71	0.97
Header laid to line	0.31	0.24
Header cut	0.39	0.00
LEADS		
Stretcher near corner	0.54	0.37
Stretcher cut near corner	0.19	0.85
Header near corner	0.39	0.34
Header near corner cut		
Brick at corner	0.93	0.69
Brick cut at corner	1.77	1.45
Leveling	0.05	0.00
Plumbing	0.24	0.11

JAMBS	FACE SELECTED	BACKING BRICK
	Time per Brick	Time per Brick
Brick at jambs to line . . .	0.75	0.33
Brick cut at jamb for bond . .	1.05	0.45
Plumbing jamb	0.38	0.11
Laying return	0.54	0.37
Laying cut brick on return . .	0.70	0.47

The formula method of figuring the standard times for the various combinations of elements is not so complicated as it looks on the surface and has proved satisfactory in many cases. It allows for recombining the elements in every possible way, as it is necessary to do on construction work. Where it is *not* necessary to make a new recombination of elements for practically every job, however, the simpler the form in which the standard times are expressed the better.

Availability of Data

The data, from which the final summaries are drawn, are gathered together at considerable expense of time and effort. They should be kept preferably in a folder with all of the information pertaining to the operation, so that it will be accessible whenever needed. This information may be of use in: (1) Furnishing information to the planning department; (2) furnishing estimates to the sales division as to the cost of new work; (3) altering the standard times of the operation because of some marked change in the machinery, equipment, or methods; (4) determining standards on some other operation, which in some cases may be entirely new.

By making this information available the planning department knows the time it will take to perform each operation. It can, accordingly, arrange the work so as to get, as nearly as possible, the maximum of production from the plant. With

standards the work can be intelligently directed—a condition which is impossible where crude estimates alone are avaliable.

The estimates furnished to the sales division will, because they are carefully organized, eliminate the necessity of adding an extra percentage of time in order to cover all unforeseen delays in production. Standards also make possible an accurate predetermination of the maximum output of every department, so that the sales division can be given a definite date of shipment for every order that is received. Another advantage is that the planning department, when controlling definite information, can notify the sales division some months in advance as to the kind of work the factory could use in order to keep all the machines busy for the greatest amount of time. Both of these factors are valuable to any company. By fulfilling promises that have been given to customers the company builds up a satisfied clientele. The company will also know well in advance all the needs of the factory, and as a result of this foreknowledge the costs of production will inevitably be less.

The third point, viz., altering the standard times, usually results from the introduction of new machinery or new methods. By keeping all of the original standardization data properly filed and indexed, it is possible to use this information in figuring out the new standards. In some cases it may be necessary to make but a short study on the time of the elements originally taken. Such a precaution materially reduces the amount of time of studying new standards.

Occasionally in determining standards on another, perhaps a new, operation, the elements are identical with those which have been standardized and are in use. When instituting new standards it is not necessary to study the operation for a new standard. In making the original studies, the time taken by each element was found and the standard time for this element was set. Many elements appearing in one operation will be found to appear in other operations, although in different

sequence, or, perhaps, supplemented by other elements. It is, therefore, possible to take the standard time values of the elements that have previously been determined and add to them the allowances which are necessary for the new operation. In this way it is possible to reduce the number of time studies and analysis, as well as the amount of computing, that appear necessary in establishing new standards.

The detail time studies, the standards that have been set, the reasons for setting the standards, the tabulations, the curves, the instructions, and the final summaries should be grouped for each operation. All information about each operation should be kept in a separate folder and indexed. By following this method, the information will at all times be available and any duplication of work will be unnecessary.

CHAPTER XVIII

EXPLAINING THE STANDARDS

There are two groups upon the efforts of whom the success of the standards depends—the management and the employees. But as both are materially affected by the standards, neither should be expected to accede to any innovation unless facts that command their confidence are presented to substantiate the claims of the analyst. An application of the conclusions must, therefore, be preceded by a thorough explanation of the principles and the standards.

The executive is chiefly concerned with the relative costs under the existent and under the proposed plan. He expects to have definite facts presented to him so that he may know how much production to expect, how large a wage he must pay employees and what the unit costs will be.

The employee, with good reason, is suspicious of changes affecting his job unless he is sure exactly what they mean. He wants to know what the standards consist of and how they were determined. Most especially he wants to know how they are going to affect his earnings. If the method of payment adopted is time work with bonus, which is something new to him, he naturally wants to know just "how it works" so that he can figure his pay for himself and understand each week any variation in its amount.

Explaining Standards to Employers

The three points the executive is interested in are:

1. Increase in production
2. Increase in wages
3. Decrease in cost

The explanation given him should therefore treat these points fully. The increase in production and increase in wages should be shown in percentages, because their proportionate increase is the objective sought. As regards decrease in cost, however, dollars and cents are what count. The executive is not particularly interested in a saving of $50 a year, but he is very much concerned if a saving of $50,000 a year is made.

An important point to bear in mind is that all such estimates of relative costs must be based on actual records. The necessity of getting exact data from which a comparison of the previous and estimated costs can be made has been taken up fully in Chapter XVI. In drawing the comparison, the figures should not only be taken from company records when possible, but they should be chosen and examined carefully to make sure they are applicable. There is danger of using figures which cover so long a period of time that the conditions are not identical with those used to show estimated production, or of using the wrong basis of comparison—taking pounds when yards or some other unit of measure should have been taken. Attempts to compare things which are not comparable result in confusion and misunderstanding.

In fact the sources from which figures are obtained have such a vital effect on the accuracy of the actual result that an explanation of how the figures were obtained should be stated first in the report on estimated savings. This should be followed by a statement regarding the way in which the figures thus obtained were worked up. The best way of describing this method of figuring the saving is to take an estimate and discuss it in detail step by step. The estimate here chosen is one pertaining to the operation of weaving wire cloth. In this case the actual times were drawn off from the company production records covering two weeks in March and two weeks in November. A list of the figures is given, according to the variables of each order.

March 16-18

Loom Number	Cloth		Length	Actual Times	Standard Times
21	¾″ # 20½	24	2,100	14.1 hrs.	12.5 hrs.
"	"	36	3,674	31.3	25.5
"	"	48	750	8.6	5.7
23	1″ #20	68	24,600	153.0	118.5
13 & 18	2″ #19	72	27,000	96.0	51.7
"	"	96	50,250	145.5	102.5
27 & 28	2″ #20	84	36,150	109.0	70.5
"	"	96	17,550	55.0	35.3
17, 19, 25	2″ #20½	60	2,400	6.5	4.4
"	"	84	3,300	7.5	6.5
"	"	96*	76,050	290.0	159.7
			243,824	916.5	592.8

November 18-30

Loom Number	Cloth		Length	Actual Times	Standard Times
22	¾″ #20½	39⅜	656	7.6	4.7
"	"	40	2,460	23.3	17.6
23	1″ #20	66	14,250	93.3	66.7
17–18, 19	2″ #19	72	90,900	205.8	173.6
"	"	78	14,550	31.6	28.4
26	2″ #19½	72	38,700	97.3	74.2
17–25	2″ #20	72	31,500	78.6	59.5
"	"	84	12,150	37.6	23.7
13	2″ #20½	36	1,500	2.9	2.6
"	"	72	22,950	82.9	43.4
			229,616	660.9	494.4
Total.............				1577.4	1087.2

* 1st symbol, space between wires. 2nd symbol, gage in width of wire. 3rd symbol, width of cloth. Ex. ¾″ space between wire; 20½″ gage wire; 24 feet width of cloth.

The percentage of increase in production is found by subtracting the standard time from the actual time and multiply-

ing this remainder by one hundred—then dividing that result by the standard time.

Expressed in a formula this reads:

$$\text{Increase in Production} = \frac{\text{Actual Time—Standard Time}}{\text{Standard Time}} \times 100$$

In the case of the weaving operation the formula is translated into the actual figures as follows:

$$\text{Increase in Production} = \frac{1577.4 - 1087.2}{1087.2} \times 100 = \frac{490.2}{1087.2} = 45\%$$

The increase in production then was 45 per cent.

Increase in Wages

After a careful consideration of all the factors involved, the analyst works out the increase in wages, which in his opinion the employee should receive, and uses this figure in making his calculations.

It will be noted that in the calculations the assumption is made throughout that the employee will earn his bonus only 85 per cent of the time, because minor delays often occur which necessitate day work. If this figure is used, there is no danger of causing trouble by overestimating the employees' earnings. There is never any complaint when an employee earns more than the amount stated, but hard feelings and ill will are inevitable if the earnings are less than anticipated. It is safe to assume, however, that production will be increased to the full amount as shown by the figures, even though the average employee earns the bonus only 85 per cent of the time. This is not only because the skilled employees will often do the work in less than the standard time, but also because even when an employee fails to do the work within the standard time, he will usually fall only slightly below the mark.

In the case of the operation of weaving wire cloth, to return to the specific illustration, the wages original and proposed were:

Original Wages	\$ .33 an hour
Proposed Wages (assuming that standard is earned 85% of the time)	\$ .426 an hour

The percentage of increase in wages is found by dividing the difference between the proposed wages and the original wages multiplied by one hundred by the original wages. Expressed in a formula, this reads:

$$\text{Increase in Wages} = \frac{\text{Proposed Wages} - \text{Original Wages}}{\text{Original Wages}} \times 100$$

In the case of the weaving operation, the formula is translated into actual figures as follows:

$$\text{Increase in Wages} = \frac{0.426 - .33}{0.33} \times 100 = \frac{0.096}{0.33} \times 100 = 29\%$$

The increase in wages was, then, 29 per cent.

Decrease in Cost

The decrease in cost is most important in the mind of the executive. This is shown in dollars and cents saved per year. The total cost is the sum of the wages of the operation and the machine overhead. The saving in machine overhead is often a large part of the decrease in cost, so that sometimes, although the labor cost is greater, the total cost is less.

The total of the machine overhead plus the wages should be shown for the original and the proposed plans.

The cost for the weaving operation were:

Costs per Hour

	Original Plan	Proposed Plan
Overhead	$0.99	$0.99
Labor	$0.33	$0.426
	$1.32	$1.416

The saving per hour under the proposed plan is equal to the original cost multiplied by one plus the increase in production minus the proposed cost. Expressed in a formula this reads:

$$\text{Saving per hour} = \text{Original Cost} \times (1 + \text{Increased Production}) - \text{Proposed Cost}$$

In the case of the weaving operation where the increase in production was 45 per cent, the formula is translated into actual figures as follows:

$$\text{Saving per hour} = (1.32 \times 1.45) - 1.416 = 1.914 - 1.416 = \$0.498$$

It may be assumed in round numbers that in a year, with a 48-hour week, there are, exclusive of holidays and Sundays, approximately 2,400 hours. The saving per loom per year would then be $1,195.00. There were thirty-four looms used on the operation, so that the total saving on this operation from job standardization would amount to $40,630.68.

Summary of Estimate of Savings

Increase in production	45%
Increase in wages	29%
Decrease in cost per year	$40,630.68

Obtaining Approval of the Management

In addition to the estimate of savings furnished to the management, as represented by the president, manager of manufacturing, agent, or other final authority on the matter, any

further data, summaries, or explanations desired should also be provided.

The approval of the management makes the rates effective at once. The employment department should also approve the rates. Where the employees are highly organized and deal with the management under a collective agreement, the approval of their representative should also be obtained before the rates are effective.

Notification to Departments Concerned

Official notifications that the rates are effective should be given the departments concerned. Where it is practicable a blue-print copy of all time allowances, drawings, and instructions should be furnished the foreman who will post it in a conspicuous place in the department.

The pay-roll department should be given in writing the names and numbers of the employees starting on time work with bonus, a copy of the rate sheet, and a full set of rates as approved by the management.

The planning department should be given official notice of the date on which the rates will go into effect and any further information necessary. The rate-setter, the clerk who writes the time allowed for each job on the employee's time-ticket, must of course be provided with a copy of all time allowances, drawings, and instructions.

Explaining Rates to Employees

The employee is, perhaps, the most concerned of all. A full explanation must be given him also of the application of time work with bonus to his job. This official explanation should be given him even though he may be—and should be—already more or less familiar with its principles, from the explanations of the analyst while he was making the studies.

It is desirable to hold the conference in the office of the analyst where it can be less hurried than it would necessarily be in the factory. The foreman should be present. The presence of the foreman serves as a sign both to the foreman himself and to the employee that, although the new rates are not set by the foreman they will be maintained through his authority. It will also give the foreman detailed knowledge which he will need on the application of time work with bonus to each one of the operations in his department.

While the explanation must be exact, it should also be simple. The charts, curves, and method of calculating time allowances furnished the rate-setter might only serve to confuse the average employee, so that it may be necessary to use discretion as to the amount of detail to go into with him. In any case, even though the employee exhibits little or no interest, the analyst should take the time to explain everything to his own satisfaction. The employee should also be told that he will be paid for all the time required to explain matters to him at this time or at any other time he feels he would like to have something made clear.

Points to be Stressed

The chief points to be stressed are the fundamental principles of job standardization as applied to the employee's particular operation. The purpose of all the analytical study and work which the employee has seen done is to find out the best and most expeditious ways of performing the operation so as to be able to set a standard method and time that is fair to everyone. The standard times are based on the studies with which he is familiar. They are not guesses nor are they inventions for speeding up. The increased production resulting from the use of the standard method and from knowing the standard time in which the job can be completed makes it possible for the management to pay the employee more money.

If anything comes up which interferes with the employees earning the bonus, proper notification should be given. Allowance will be made to take care of conditions arising during the period of getting into the stride. The standard times are not subject to change, unless a marked change is made in the method, machinery, or equipment, reducing the amount of time necessary to complete the operation without increasing the effort on the part of the employee; so that he need not be afraid of rate-cutting when he becomes expert in the new method.

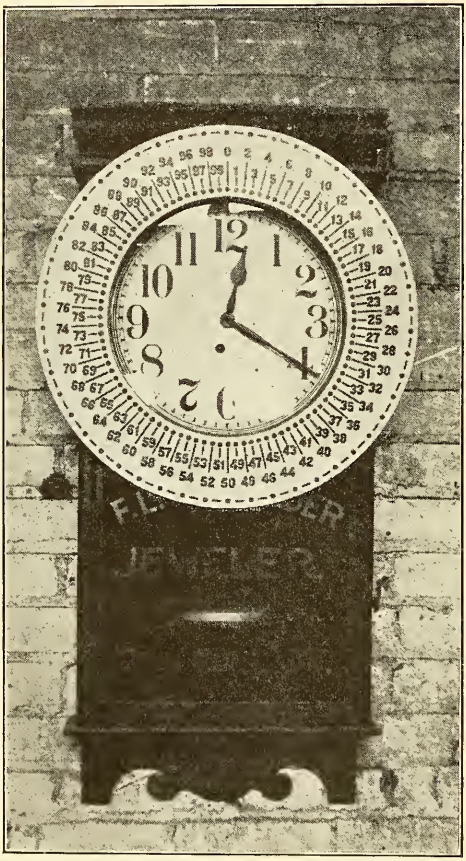


Figure 56. Decimal Time Dial Attached to a Regulation Clock Dial

This explanation by the analyst affords an excellent opportunity of giving the employee a glimpse into the principles and application of the new methods of management. At this time the employee may be shown how his output is based on the fact that the management furnishes materials to his machine and eliminates extra and unnecessary work. The fact that the work can be done in less

time than formerly is the result of the increased attention given to these matters by the management. The way in which these matters are looked after by routing, scheduling, keeping a record of materials on hand, and so forth, may be explained to him by showing sample forms.

Since standard times are expressed in hours, tenths, and hundredths, and the tickets accompanying the job are also stamped, when the employee starts and finishes it, in hours, tenths, and hundredths, he will be interested in the working of the decimal time clock. The way to make it clear is to compare the decimal clock to an ordinary clock. An auxiliary clock face or dial is sometimes used in the planning department to show the relation of decimal time hours to standard time hours. Such a dial can be made by glueing black gummed figures on to the white disc, giving the entire surface several coats of shellac, and fastening the auxiliary clock face to the clock, outside of the case, as in Figure 56.

Explaining the Pay

The employee is usually interested primarily in the extra pay which time work with bonus makes it possible for him to earn. The principle may first be explained to him in much the same way as it has been stated in this volume (Chapter XVI). A careful explanation of its application to his individual job must then be given, making sure that he understands each point. The base rate—the amount per hour he will receive—is such and such a sum. The bonus rate is such and such a per cent of the time allowed. By figuring out a number of jobs from actual manufacturing orders the analyst will be able to show him just what is meant by the base and bonus rates, and how they work in practice. Such an explanation will make clear the amount paid per job and the way in which it is figured. The total amount to which his wage will come each week, if the bonus is earned 85 per cent of the time, should

Name *Matthew Sullivan* No. *187* Date *March 8, 1920*

Your time and earnings as follows: *60¢ — 25%*

Date	Loom No.	Cut No.	Lineal Feet	Time Allowed	ATTENDANCE HOURS				Bonus Hours	AMOUNT		Time Out
					Mach.	Damage	D.W.	Overtime		Total	P.W.	
3/8/20	*R12*	*WS219R36G*	*1620*	*1.9*	*1.7*				*0.5*	*2.2*		
"	"	*WS218½R36½G*	*1520*	*1.8*	*1.7*				*0.5*	*2.2*		
"	"	*WS419R36R*	*1020*	*1.6*	*1.6*	*0.6*			*0.4*	*2.6*		
"	"	*WS219R24G*	*1620*	*1.4*	*1.2*				*0.4*	*1.6*		
"	"	*WS423R36G*	*815*	*1.3*	*1.2*			*0.5*	*0.3*	*2.0*		
"	"	*WS423R24B*	*615*	*1.1*	*1.1*				*0.3*	*1.4*		
							0.5			*0.5*		
				TOTAL								

Figure 57. Individual Employee's Pay-Roll Sheet

also be figured out for him. He should furthermore be told the weekly sum he may expect and what the increase will be over what he previously received.

He will be able to check the amount he received and the way in which it is made up by means of the records from the pay-roll department which will be sent him each day. This record is a carbon copy of the pay-roll sheet that department makes out for each individual employee. The employee's daily record sheet is given in Figure 57.

There should be none of the "take it or leave it" attitude about the conference. Its purpose should be to recognize the vital concern of the employee in the conditions of his work.

Adapting Explanations to Individuals

The matter of explaining the standards in ways adapted to the individual executive and to the employee is something which, of course, depends on the character of the men with whom the analyst is dealing. Some employees, for instance, are intelligent and interested in their work, while others can see only the pay envelope at the end of the week; still others are suspicious of any change. In this case, as always in job standardization, the analyst must exercise tact.

CHAPTER XIX

APPLYING THE STANDARDS

Methodized Application of Standards

The method for determining the standard time scientifically has been given in detail. It remains to describe the fourth and last phase in job standardization—that of applying the standards.

The time required for this phase varies with the changes made in the method of performance, and the number of employees working on the operation. It is rarely less than one-third as long as the time for the third phase, analyzing the studies and determining the standards.

Success depends largely upon the way in which the standards are applied. Whereas taking the studies and setting the standards is the most technical part of the job standardization, requiring much skill and patience, so that it is often the only aspect thought of by the uninitiated, the final step—that of applying the standards—is no less important. No matter how accurate and well established are the rates set, if the analyst cannot get the employees to accomplish the tasks and earn proper compensation his work is for nothing.

If the co-operation of the superintendent and foreman has been completely gained at the start, and the work of determining the standards has been carried out with the employees, the analyst will not meet with difficulties in applying the standards. This step, however, changes the subject of standards from an abstract possibility into a matter of immediate and vital concern to the employee and, therefore, is the test of his confidence in the analyst. Furthermore, the fact

that the time standards and the wages received are dependent upon the maintenance of all the other standards make it fatal to allow these standards to slip, as the department may have been doing in the past. For these reasons, the work of applying the standards should at the start be done either by the analyst or by an assistant under his close supervision. After the employees are all accomplishing the work according to the standards, the analyst should establish a routine providing for the proper maintenance of all the standards, conditions, method and time.

Starting Employees Individually

The standards should be applied by starting *one employee at a time.* In the case of group work this means that one group at a time should be started working under them. This method of starting each employee or group separately prevents friction and misunderstanding. It, moreover, helps each employee to reach the standard in the shortest time possible, because it gives him attention, allowances for delays, and instruction adapted to his particular needs. After the first three or four employees have proved by their example that the standards are correct, the rest of the employees may be started in quick succession.

This individual attention to the misapprehensions, difficulties, and desires of each employee is necessary because the new time-standards represent a change in principle, not only over day work but even over the usual piecework systems. Instead of being left to his own devices to produce the most he can in any way he wants, the employee is suddenly given a very definite measure of performance and expected to live up to it. Some employees, who have been jogging along using methods they worked out for themselves which are not the best, find the sudden change of method difficult, and naturally blame the standards instead of themselves, unless they are

helped over the period of transition by explanation and instruction.

Starting Employees Simultaneously

There may be circumstances making it necessary to modify or even to lay aside this principle and start all the employees simultaneously. Such a circumstance would arise where the rates were being introduced in response to long-continued pressure for their readjustment, where the patience of the employees had reached a limit, and the management was unable to hold them off any longer. But only extreme cases justify starting all the employees simultaneously.

An example of the trouble which was caused when an analyst made the mistake of introducing the rates by starting all the employees at once, occurred on the operation of collating calendar pads. The studies had been made on skilled employees with the resulting curve shown in Figure 58. From the hour they started the first job on time work with bonus, these same skilled employees on whom the studies had been made failed to earn the bonus. They maintained it was not possible to do the work in the time allowed. The standard times were checked, so that the employees could see that they were being treated fairly. The check studies showed that the men were doing the work more slowly than at the time the original studies were made. In fact, the difference between the times taken in the original studies and those taken in the check studies averaged 40 per cent. The curves in Figure 58 show the times marked X taken by the skilled employees previous to setting the new rates. Crosses with the notation B (xB) show the times taken after the new rates had been put into effect, when the employees put on the brakes and began to work slowly.

The reason was that the skilled employees who were failing to make the standard times were close friends and in all prob-

ability had agreed among themselves not to earn the bonus in the hope that the standard time would be increased. An interesting comment on the situation was that one of the employees,

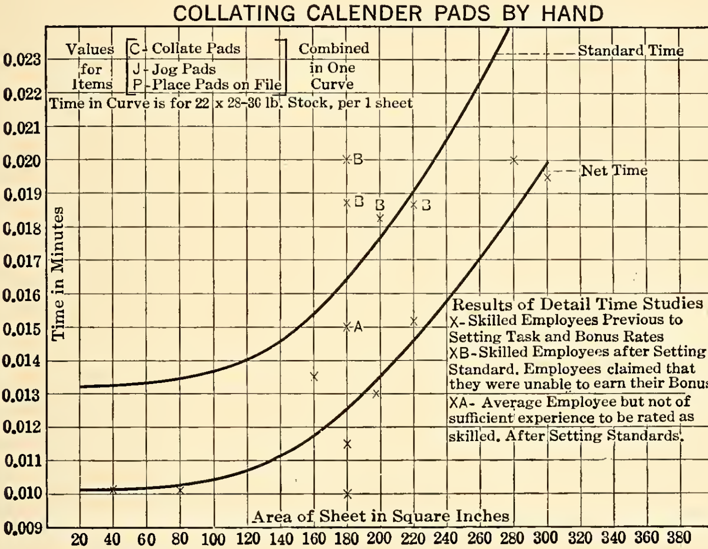


Figure 58. Chart Showing Comparison of Times Taken by Skilled Employees before and after Standards Were Set with the Standard Time Curve

an average worker, but not of sufficient experience to be rated as first class, actually did the work in less than the time allowed by the analyst. This man had not been long in the employ of the company and was not a member of the clique. His time is marked on the chart as xA.

The analyst held a conference with the employees in which he explained the situation thoroughly. They returned to the work and made the standards. The trouble, however, should have been avoided in the first place by starting one employee at a time and explaining the rates to him before asking him to work under them, and then starting others singly until they all were convinced of the accuracy of the time standards.

Instructing Employees

The matter of proper instruction is very important in the application of the standards, especially if changes have been made in the handling of the work. Instruction is an essential part of the program of job standardization. The standard times are based on the "best" method and procedure, the determination of which is the result of careful study. If the employees fail to follow this "best method" they will probably do one of three things: be unable to complete the work in the standard time; complete the work in the standard time, but fall down on quality; or complete the work in the standard time and of the standard quality, but fatigue themselves by not going about it in the right way.

Economy of Methodized Instruction

If the management, then, expects either a large quantity or a first-class quality produced, it must assume responsibility for showing the employees the methods which make for quality and quantity production. Standards of work cannot be maintained if each new employee is let loose, so to speak, in the department, given a number and a work place or a machine, instructed occasionally by an old worker who looks on him as a nuisance, and supervised by an overworked foreman. Under such rule-of-thumb methods it takes months to break in a workman even on the simplest operation. Although the old employees who have been "trained up"—if it can be called training—under this antiquated system, may have acquired skill through long years of practice, even they do not often make use of the best methods, because no one has taken the pains to study the operation and bring together the most effective ways of performing each of its elements. Proper instruction helps the employee to become skilled in the shortest possible time. Under ideal conditions every operation or group of operations is under the direction of a special instructor. Em-

ployers are beginning to realize that such practice is economy—not expense. Some few concerns even go so far as to offer training courses for beginners. The training course teaches the beginner his job entirely away from the department in which he will be placed later under special direction.

The Instruction Engineer

A recent development in industrial work is the profession of "instruction engineer." The instruction engineer is a member of a concern of consulting engineers in industrial management and is sent to serve clients who appreciate the economy of instructing their employees in methods of work. The instruction engineer starts a definite plan of instruction adapted to the needs of the factory and teaches men from the client's own organization how to act as instructors. His work should *follow,* not precede, job standardization. The instruction engineer should not attempt to determine the best methods, because he does not have the same opportunity to do so as the analyst. He takes the methods which are commonly accepted as the best and shows how they can be taught in the best way. If job standardization already has been undertaken, the methods which he teaches are the best methods under present conditions, since their determination is the result of detailed study.

Duties of Instructor

The duties of the regular instructor should be clearly limited and defined. The instructor should be responsible primarily for the quantity produced, he should also be responsible for attaining the speed of rhythm which gets quality as well. His duties are:

1. To teach new employees.
2. To show all employees the best methods.

3. To make sure that they are capable of following them.
4. To make it easy for the employees to do the work by seeing that they are supplied with material and tools.
5. To maintain quality.

Foreman and Instructor

The relation of the instructor to the foreman and others in authority should be made absolutely clear. A strong foreman is prone to curtail the instructor's powers too much. On the other hand the instructor who has a weak foreman will sometimes exceed his authority. The instructor is answerable to the foreman for his own conduct, but not for the conduct of the employees whom he is teaching. He should be able to call on the foreman's authority whenever he feels that it is necessary.

Analyst and Instructor

The instructor assists the analyst during the period of introduction of time work and bonus. Since he is on the spot all the time, he will be able to see that the employees are provided with equipment, materials, and every facility for doing the work in the standard time. He will be able to show the employees why they fail to earn the bonus and where their methods are faulty, and to teach them the new methods when they are not already familiar with them.

On operations where there is no instructor the analyst may be obliged to be responsible for teaching new methods. This does not mean that he will put on overalls and take the machine in hand himself, which is never advisable even were it practicable. The analyst has a working knowledge from observation of all the operations studied. If he were to attempt to acquire the expert knowledge necessary to demonstrate to the skilled employees how the work should be done, he would have little time in which to make studies. Besides, it is not necessary

for the analyst to make an actual demonstration as his method consists of taking stop-watch observations of a workman who is to be instructed and from these studies telling the workman wherein his method differs from the standard and in what elements he takes more time than standard. In case it should be necessary to make an actual demonstration to the workman the analyst calls the foreman or some other skilled employee to his aid.

Following Up Employees

In any case, it is better for the analyst or for one of his assistants to devote a major part of the time to following up the work of the employees who were first to be started under the new standards, because there are innumerable complications which arise during the first few weeks when the standards are being put into effect. Someone must, therefore, be in the department almost constantly, correcting unfavorable conditions, answering questions, and generally seeing that the change from the old method to the new is made without friction.

Eliminating Unforeseen Complications

Complications arise when material fails to come through as scheduled or when it is imperfect in quality, or when any other condition falls below standard, and at first the attempt to hold conditions strictly to standard involves constant effort and attention. That is why the analyst or assistant should be in touch with the employees, so as to be sure their effort is not relaxed. The situation, however, soon should straighten itself out, as the entire department begins to realize the cost of letting the standards fall. Since each case which does occur must be noted in order to give the employees a proper allowance of time, it is easy to figure the reports of time lost in dollars and cents. This will bring forcibly to everyone's attention the magnitude of small delays.

Answering Employee's Questions

Another reason why a member of the job standardization staff should be almost constantly in the department in which the standards are being applied is that during the time the employee is adjusting himself to the new standards, he is sure to ask many questions. Although the explanation to the employee described in Chapter XVIII should already have answered these questions, it is while the employee is actually working on the operation that he can best understand the answers.

The employee is especially likely to make comparisons between the standard times allowed for different jobs. If the relation is not what he would have expected he wants to know the reason. In order to make it clear the analyst will have to explain the different requirements of the two jobs, showing how the method of calculating the standard time is applied to them and pointing out just where the differences in the time occur.

Making Allowances for Standards

While the employee is getting into the stride, additional time is sometimes allowed. The employee in starting to work according to the standards may be anxious to make good and actually take more time than he realizes though he may feel he is working extremely well. It takes a certain amount of time for him to become familiar with any changes which have been made. The extra time allowed should be definitely stated on the employee's time ticket so that he may know exactly the amount allowed. In some cases 20 per cent extra time may be allowed on all jobs worked on during the first week, then 10 per cent for the second week, 5 per cent for the third week, and no allowance from then on.

A definite percentage allowance for stated periods over and above the standard time is not always used; it is not one which the author advises. Instead it is better for the analyst

to give individual allowances where it is justified for special instances of failure to make the standard. During this introductory period an allowance may often be given when the failure is not really due to the fault of the employee, as for instance, as the result of unfamiliarity with new methods. Since each employee is being considered separately and treated as an individual, the analyst may grant special allowances because he knows the particular circumstances that make it desirable.

During the period of follow-up, all tickets showing whether the standard has been reached or not will be sent to the analyst before being sent to the pay-roll department. This is very important, because it informs the analyst *at once* of failures to make the standards. He can then investigate the cause before it is buried in oblivion. If the cause warrants it, he can, before the daily earnings are figured, make any adjustment or allowance due the employee.

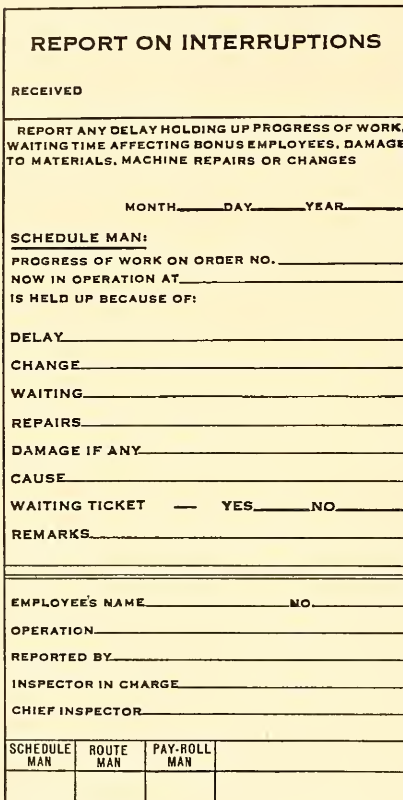
Maintaining Standards

Even after the employees are all "over the top" and are capable of making the time standards practically all the time, the analyst should not consider that his responsibility has ceased. From one point of view this last phase, "applying the standards," is never finished. The permanent work involved in it, however, may be reduced to a routine, requiring little time or attention.

The time standards set by job standardization are dependent on all other standards. In other words, if the material is in poor condition or does not come through on time, or the machine is out of repair, or other delays occur, the employees cannot make the time standards. Therefore, the analyst, instead of leaving this to be reported by the foreman, should institute routines which will automatically call to his attention or to that of those responsible the reason for the failure when results fall below standard.

Recording Delays

A record should be made of any unusual delay occurring in connection with the operation, giving the cause and the time lost. A standard form for this use, called a "Report on Interruptions," should be instituted. This form is shown in Figure 59. It should be used when necessary, but should not be abused. If materials are not up to standard, if they are delayed, of if a machine breaks down, a report on interruptions should be issued to cover the situation. The report should be signed both by the foreman and by the head of the planning department. This will help to prevent any abuse. It also brings the delay forcibly to the attention of those who may be considered responsible for it. Although the report on interruptions may be used in adjusting the pay-roll where the failure to earn the bonus is not the fault of the employee, it should be used primarily for calling the attention of all those executives who are responsible to conditions which ought to be corrected.



REPORT ON INTERRUPTIONS

RECEIVED

REPORT ANY DELAY HOLDING UP PROGRESS OF WORK, WAITING TIME AFFECTING BONUS EMPLOYEES, DAMAGE TO MATERIALS, MACHINE REPAIRS OR CHANGES

MONTH____ DAY____ YEAR____

SCHEDULE MAN:

PROGRESS OF WORK ON ORDER NO.____

NOW IN OPERATION AT____

IS HELD UP BECAUSE OF:

DELAY____

CHANGE____

WAITING____

REPAIRS____

DAMAGE IF ANY____

CAUSE____

WAITING TICKET — YES____ NO____

REMARKS____

EMPLOYEE'S NAME____ NO.____

OPERATION____

REPORTED BY____

INSPECTOR IN CHARGE____

CHIEF INSPECTOR____

SCHEDULE MAN	ROUTE MAN	PAY-ROLL MAN	

Figure 59. Regulation Report on Interruptions

Bonus Allowances

When extra allowances are given to the employee for the first few weeks he starts to work on new standards, confusion sometimes occurs as to how to figure the bonus. The agreement with the employee when he starts working on standard production is that he shall receive, aside from his day's work, a bonus based on the standard, provided he accomplishes the work in regulation time. If then, in starting out, the company allows him extra time over and above the standard time, he should not expect to receive besides this a bonus on the extra time. Because of the error of paying a bonus on the extra time allowed, hard feelings may often arise when the employee finds that, after the allowances are no longer being made, he does not get as much money as he did when he started the work under the standards.

Daily Production Record

Another routine which prevents employees' falling below the standards is the institution of a graphic record of the daily

PAY-ROLL SHEET

NAME ____________ CHECK NUMBER ____________
CLASS OF LABOR ____________ PIECE RATE ____________
SHEET NO. ________ TOTAL ________ DAY WORK RATE ____________
PAY ENDING ____________ BASE RATE ____________

	Date	Time Issued	Time Returned	Machine Symbol	Job Number	Quantity	Time Allowed	ATTENDANCE HOURS					Bonus Hours	Earnings	Time Out
								Mach. or Wk. Place	Damage	Day Work	Overtime A	Overtime B			

Figure 60. Typical Pay-Roll Sheet

output of each employee as measured by his earnings. This record may be kept by the employment department, which, in

order to know whether employees are making good, must be familiar with the work they are doing.

The pay-roll department is obliged to keep a daily record of the earnings of each employee. These may be made out by hand on a sheet like the one shown in Figure 60 or may

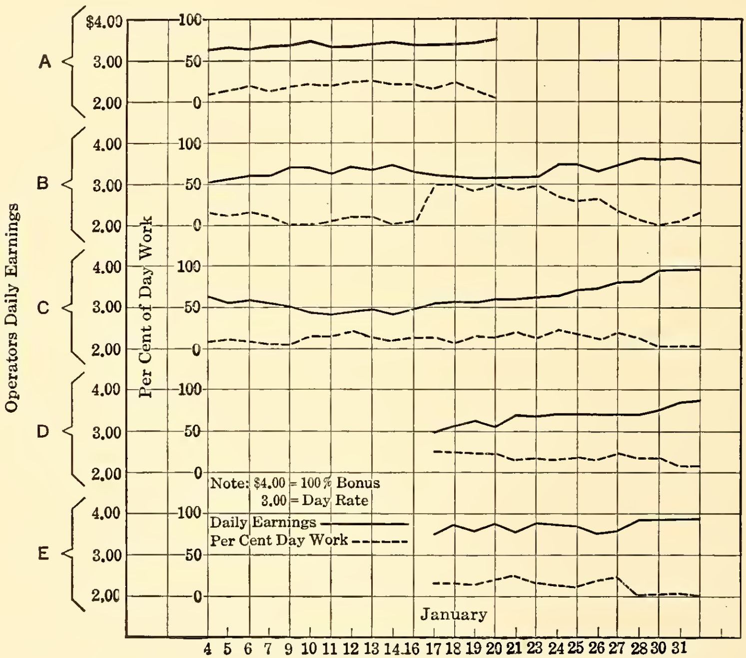


Figure 61. Chart Showing Daily Earnings of Employees

be made on a tabulating machine, if there are a great many employees. After the weekly pay-roll is figured the individual reports should be turned over to the employment department. The figures should there be drawn off on charts which show the daily earnings in graphic form.

A daily record chart of this sort is given in Figure 61. The chart shows the earnings made during the first month the

employees were on time work with bonus. When the operators earned the bonus 100 per cent of the time they made $4 a day, while if they were unable to do the work in the standard time they made only $2. The solid line indicates the daily earnings, while the dash line shows the percentage of day work. By the end of the month most of the employees were earning almost 100 per cent bonus, and the amount of day work (which in the middle of the month had been very large) was greatly reduced.

The analyst will look into all cases where any employee fails to earn the bonus 85 per cent of the time, or if the amount of day work shows an appreciable increase.

Completing Job Standardization

The institution of these routines for maintaining the standards marks the completion of job standardization on the particular operation. The standards determined are now in effect, and both the management and the employees are getting the benefits of the resulting increase in production. Instructors are teaching new employees, so that the standard methods and times are becoming a part of the tradition of the factory, handed down from the older generation of workers to the younger. The fact that the time standards are dependent on the standards of condition and that the maintenance of the time standards is being checked by the graphical record of daily earnings acts as a check on all the standards of production.

CHAPTER XX

PERPETUATING THE STANDARDS

Establishing Routine for Perpetuating Standards

The responsibility of the analyst in applying the standards has not ceased until he has devised some means of making them "self-applying." From one point of view, applying the standards is never completed. Even when all the employees are capable of making time standards under standard conditions, there must still be some way devised for holding conditions to standard. The management should continuously know how nearly the actual conditions, as regards the work of the employees, the state of the machines, and the like approach the standard. In order that the management should be so informed the analyst must devise routines which require as little time as possible and which may be carried out by clerks, but which will show the executives a summary of the situation.

Graphical Charts for Perpetuating Standards

The best means to give the executives a comprehensive view of the production situation at a glance are graphic charts which may be made to combine, in the briefest and most effective form, a picture of what the factory should do with what it actually is doing.

These graphical representations of facts provide executives from the lowest to the highest with a summary of the situation. The amount of detail to be presented to any executive depends upon his particular duties. The manager of manufacturing needs information which will assure him that the stream of production is flowing smoothly, and which will help him de-

tect any error that may interfere with the standard output. Each executive below the manager of manufacturing requires information about his particular part of the work and—whether the amount of detail shown is large or small—the charts should summarize the situation. They should give in concentrated form the status of the factory at all times and the results that are being obtained in each department, so that the executive may keep his finger on the pulse of the business. Whenever the results look unsatisfacory or questionable he should take immediate steps to have the conditions remedied. The charts should show:

1. Per cent bonus earned by employees working on standdardized work—key to the proficiency of the workmen.
2. Production record—actual production in comparison to maximum.
3. Analysis of machine time—down time; repair time; make-ready time; running time.
4. Weekly analysis of department time—work paid for which is on a task basis; work paid for which is on a piecework basis; work paid for which is on a day work like—
   (a) Supervision.
   (b) Handling materials.
   (c) Productive work not on a task or piecework basis.
5. Delayed time.
6. Proficiency of department.

Graphical Reports

The following charts and reports are being used in a certain factory to provide a mechanism which shows in concentrated form the status of the factory at all times:

1. Daily production record (see Figure 62)
2. Daily record of production and machine time (see Figure 63)
3. Daily analysis of machine time (see Figure 64)
4. Daily bonus report (see Figure 65)
5. Daily analysis of time work with bonus (see Figure 66)
6. Weekly analysis of the distribution of the pay-roll (see Figure 67)
7. Weekly analysis of the proficiency of the department time (see Figure 68)

Separate reports and charts are made out for each department. The reports are filed in loose-leaf binders and are placed on the desk of the planning superintendent. They are consulted by him and by the process superintendent daily. Charts are also installed in the office of the manager of manufacturing where he may consult them each day and in this way keep himself informed as to the situation.

Daily Production Record

The daily production record (Figure 62) is particularly valuable when machines are an important factor in the cost of operation. For instance, in a paper-mill the hourly rate on the machine which makes the paper is about $15. This represents the overhead expense which the machine must absorb for each hour that it runs. It also makes clear the necessity for running the machine as many hours as possible. This rate does not include the wages of the men operating the machine—only such expense as power, depreciation, and repairs. The daily production record is an important medium for keeping track of the actual performance. It shows:

1. *Standard Production for Standard Running Time.* This shows the amount the machine should turn out after

making proper allowances for getting it ready (technically known as "make ready") and for other necessary delays. This is represented on the chart by the dotted lines.

BOX-MANUFACTURING DEPARTMENT

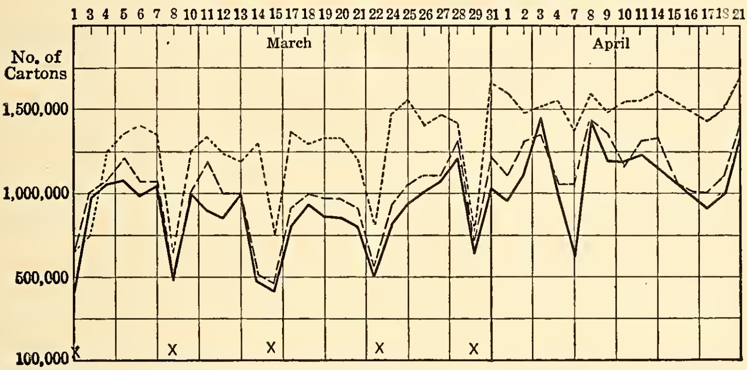


Figure 62. Graphic Chart Giving Daily Production Record:

(a) Standard production for standard running time represented by - - - - - - - - - - - - - -

(b) Standard production for the time the machines are actually running represented by — — — — — — —

(c) Actual production represented by ━━━━━━━━

(d) x designates Saturday

2. *Standard Production for the Time the Machines Are Actually Running.* This shows the amount the machines should turn out while actually running. It is represented in the chart by the dash lines.

The difference between the dotted line and the dash line indicates the loss in production due to the "make ready."

3. *Actual Production.* The actual production is represented by the solid line.

The difference between the dash line and the solid line represents the loss in production which is due to the fact that the workmen do not get the standardized amount of production from the machines.

The data for the chart on the daily production record is computed from the daily record of production and machine

CARTON DEPARTMENT

DAILY RECORD OF PRODUCTION AND MACHINE TIME

Mach. No.	Order No.	Oper. No.	PRODUCTION OF CARTONS OR SHEETS	MACHINE TIME							No. Work Sched.	No. Help	First Task Product per Hour	Standard Production	
				Running Time	WAITING FOR									For Time Mach. are Running	For St'nd'rd Running Time
					Make Ready Time	Make Ready Oper.	Oper.	Work	Repairs						
CM-1															
CM-2															
Total															
CC-1															
CC-4															
Total															
SA-1															
SA-7															
Total															
Total															

Figure 63. Daily Record of Production and Machine Time

time. (See Figure 63.) The data is first posted on the daily record direct from time tickets of the job. Items 1 and 2 are then computed as follows:

1. *Standard Production for Standard Running Time.* The method of finding the standard production for machines running a predetermined part of the total possible running

time may be found by a description of the way in which it was computed for a particular class of machine. Ten per cent of the total possible running time was required on machines of this class for "make ready" and 5 per cent for machine adjustments and small repairs. The time remaining was 85 per cent of the total possible running time and was taken as the standard running time of each machine.

2. *Standard Production for the Time the Machines Are Actually Running.* Standard production is that output which would be obtained by employees earning the first bonus. The standard production for the time which the machines are running is equal to the production per hour of the employee earning the first bonus, multiplied by the number of running hours of the machine. The standard production for time which machines are running, and for all machines in one group, is the summation of the standard production for each machine in that group.

3. *Actual Production.* The actual production which the machine turns out on each order is shown on the machine feeder's time ticket and therefore requires no such computing as items 1 and 2. The value is taken direct from these tickets.

There were six machines of this type in the department of the plant referred to. The plant was run on a 48-hour week, so that its possible running time was equal to 8 hours and 40 minutes for 5 days a week and 4 hours and 40 minutes for one day a week. Since there were 6 machines of this particular class, the standard running time for 1 full day for all these machines was equal to:

8 hours 40 minutes $\times$ 6 = 52 hours, total possible running time.

85% of 8 hours 40 minutes = 44 hours 10 minutes, total standard running time.

The standard running time for each short day was equal to:

4 hours 40 minutes $\times$ 6 = 28 hours, total possible running time.

85% of 4 hours 40 minutes = 23 hours 48 minutes, total standard running time.

In other words, the relation between the standard production in running time and the standard production in 85 per cent running time is the same as the ratio between the actual running time and 85 per cent running time.

As expressed in a formula, the standard production for 85 per cent of the running time is equal to:

$$\frac{\text{Total Standard Production in Actual Running Time}}{\text{Total Actual Running Time}} \times 85\% \text{ of the total possible Running Time}$$

This method of collating the daily production information and the record of machine time should take the place of the records which are usually kept by the foreman's clerk. Such foremen's records are more or less inaccurate because of the failure to obtain necessary information in sufficient detail to disclose actual conditions in the department. Consequently they do not show the facts as well as graphical charts would. By close attention to these graphical charts the planning superintendent and the process superintendent are able to discover the points at which it is necessary to bring pressure to bear to increase the output and to keep the production uniformly up to the maximum.

Daily Analysis of Machine Time

This record, like the daily production record, is most important when the machines are a factor in the cost of an operation. (See Figure 64.) It shows:

1. Running time (represented by heavy solid line).
2. No work scheduled (represented by dot and dash line).
3. Waiting for repairs (represented by dot line).

4. Waiting for "make ready" (represented by dash line).
5. Waiting for work and workmen (represented by light solid line).
6. Total machine hours per day.
7. Standard machine hours per day (15 per cent allowed for "make ready" and machine adjustments).

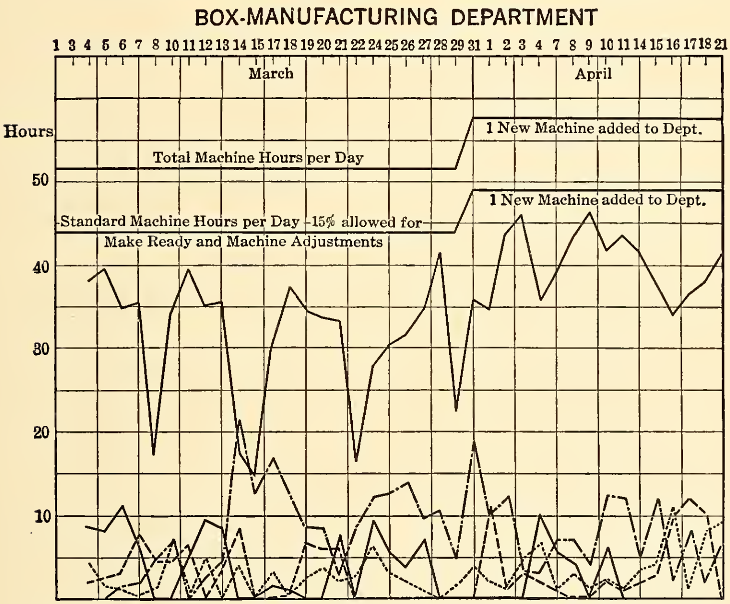


Figure 64. Graphic Chart Giving Daily Analysis of Machine Time

(a) Running time ————————
(b) No work scheduled - - - - - - - - - -
(c) Waiting for repairs - - - - - - - - - - - - -
(d) Waiting for make ready — — — — — —
(e) Waiting for work and workmen ————————

1. Running time—this running time is copied direct from the machine feeder's time ticket.
2. No work scheduled.
3. Waiting for repairs.

4. Waiting for "make ready"—the time waiting for "make ready" is taken direct from the time ticket of the workmen doing this work.
5. Waiting for work and workmen—these three items are taken from a special ticket for delayed machine time.
6. Total machine hours per day—the total machine hours per day for a group of machines is equal to the number of possible running hours per machine (without any allowance) multiplied by the number of machines in the group. This is a constant value and is only increased or decreased as a machine or machines are added or eliminated. This is shown by break in curve on March 31st when a new machine was added to the group.
7. Standard machine hours per day—this curve is parallel to curve for item 6, but is 15 per cent lower in value, which is an average allowance to take care for the time necessary for "make ready" and machine adjustments.

Daily Analysis of Time Work with Bonus

The data for the chart is taken from the daily bonus report (Figure 65). The daily bonus report shows just what bonus is earned. If no bonus is earned on the ticket, it is posted in flat-time column.

Each morning before nine o'clock a clerk should figure on the daily bonus report the percentage of tickets on first, second, and third bonuses, and on flat time, for the previous day.[1]

The result of the daily bonus report should be plotted each day by nine thirty o'clock, on the graphical chart (see Figure

[1] This illustration is taken from a factory where the work is entirely seasonal, making it necessary to have the employees work on different operations according to the particular season. For this reason it could not be expected that all the employees should be developed in a short season to the highest efficiency. The graded plan of payment is an equitable means for taking care of a condition of this kind.

PLEASE SEND THIS REPORT TO	
CHECK WITH INITIALS	HERE
RECORDING SECTION	
TIME & JOB ANALYSIS	
FOREMAN	
PRODUCTION MAN	

DAILY BONUS REPORT

________________ DEPARTMENT

DATE____________________192

	NO. 1 BONUS		NO. 2 BONUS		NO. 3 BONUS		FLAT TIME		REMARKS
R.C. FEED AND CATCH									
P.P. FEED									
R.P. FEED AND CATCH									
A.G. FEED AND CATCH									
H.G. FEED AND CATCH									
A.G. INSPECTION									
SEPARATE AFTER P.P.									
SEPARATE AFTER R.P.									
TOTAL									
PERCENTAGE									

TO OBTAIN PERCENTAGE ADD TOTALS OF NO. 1. NO. 2. NO. 3 AND FLAT TIME COLUMNS THEN DIVIDE TOTAL OF EACH BY TOTAL OF ALL COLUMNS.

SIGNED ____________________

Figure 65. Daily Bonus Report

66), showing the percentage of first, second, and third bonuses, and flat time, as follows:

Percentage of first bonus (represented by dot and dash line)
" " second " (" " dash ")
" " third " (" " solid ")
" " flat time (" " dot ")

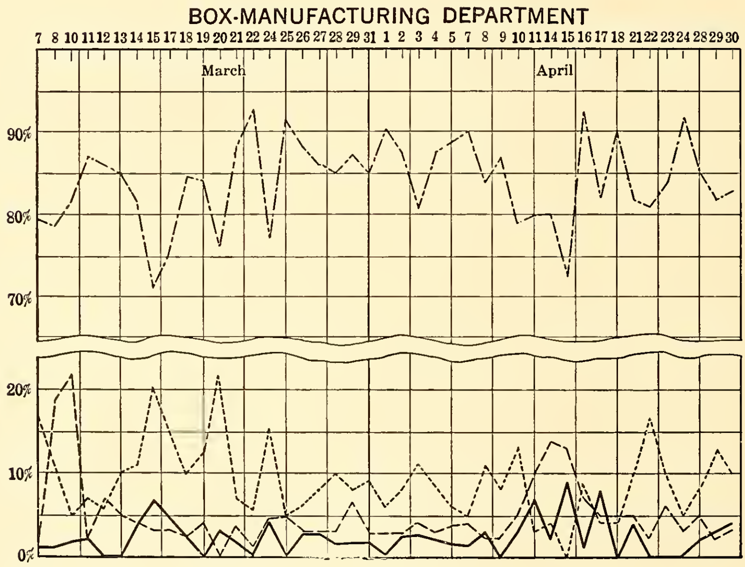


Figure 66. Graphic Chart Showing Daily Analysis of Time Work with Bonus

(a) First Bonus ————
(b) Second Bonus ————
(c) Third Bonus ————
(d) Flat Time ------------

Weekly Analysis of Departmental Time

The chart (see Figure 67) is of particular interest to the planning superintendent in assisting him to keep the non-productive labor at a minimum.

The data for the analysis of department time should be taken from pay-roll sheets.

The data for the curves showing the analysis of department time should be entered on the pay-roll sheet as soon as pay-roll information is posted in the pay-roll department.

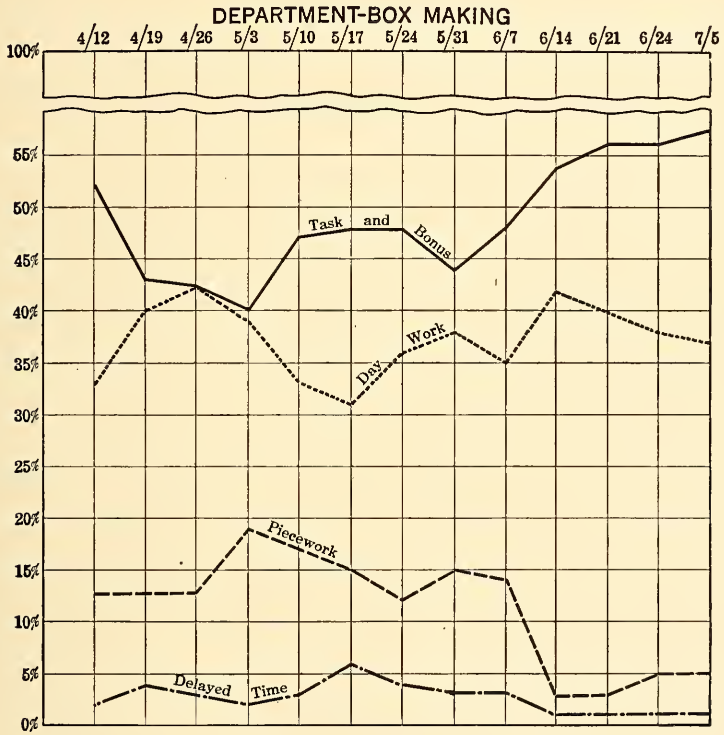


Figure 67. Weekly Analysis of Distribution of Pay-Roll

Immediately on closing the pay-roll sheets for the week the pay-roll department will take the data necessary for computing the chart from the pay-roll sheets and report this information to the planning department. This report shows:

1. Percentage of total time paid for on a basis of time work with bonus (represented by solid line)
2. Percentage of total time paid for on piecework basis (represented by dash line)
3. Percentage of total time paid for on a day work basis (Day work includes: supervision; handling materials; production on a day work basis) (represented by dot line)
4. Percentage of total time which is charged to delayed operations (represented by dot and dash line)

Weekly Analysis of Departmental Proficiency

The weekly analysis of departmental proficiency chart shows the executives the true conditions existing in his factory.

The data for computing the percentage of standard output obtained by workers paid on a basis of time work with bonus is taken, once each week, from the daily bonus reports and is computed as follows:

Example of figuring proficiency of a department:

BONUS EARNED DURING WEEK

DEPARTMENT

	1st Bonus	2nd Bonus	3rd Bonus	Flat Time
Mon.	60	20	10	10
Tues.	40	40	15	17
Wed.	80	29	30	5
Thurs.	50	30	42	12
Fri.	70	16	18	28
Sat.	60	37	8	27
Total	360	172	123	99
Percentage ..	47.5%	22.8%	16.3%	13.1%

The relation of second bonus, third bonus, and flat time to first bonus is as follows:

1st	bonus	shows	that	employee	is	100%	proficient.
2nd	"	"	"	"	"	85%	"
3rd	"	"	"	"	"	70%	"
Flat Time		"	"	"	"	50%	"

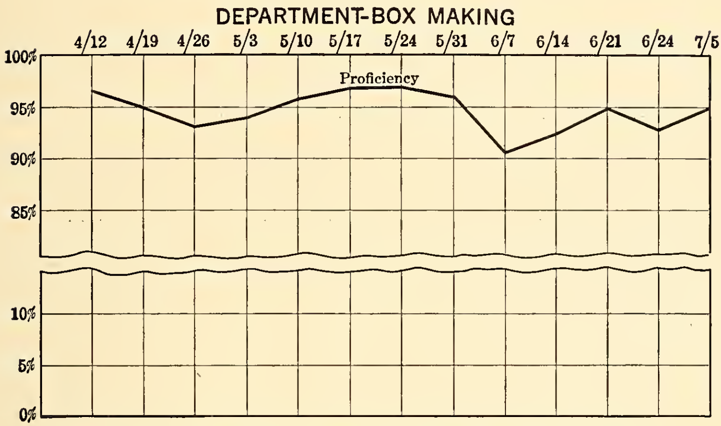


Figure 68. Weekly Analysis of Departmental Proficiency

The percentage of standard output actually obtained by employees paid on basis of time work with bonus is equal to:

1st bonus	47.5%	of	100%	equals	47.5%
2nd "	22.8%	"	85%	"	19.4%
3rd "	16.3%	"	70%	"	11.4%
Flat time	13.1%	"	50%	"	6.5%
					84.8% Proficient

After the above computations have been made and checked the clerk will plot the results (Figure 68) and file the computations in the planning department file.

Completion of Job Standardization

The principle of these charts and reports may be applied to any business, although some of the details may be only adapted

to the needs of the case in question. The data on which these charts are based are found through job standardization. Their greatest value is the mechanism by which the standards set by job standardization is perpetuated.

Until he has set up some such routine as is given in these charts the work of the analyst cannot be said to be fully developed or complete. The standard methods and times should be a part of the tradition of the factory, handed down from the old generation of workers to the new. They should also be constantly brought to the attention of the management, in the office, and constantly checked, maintained, and improved. In this way they will become perpetual, and the management and the employees will reap the benefits of continually increased production.

CHAPTER XXI

SCIENTIFIC MANAGEMENT AND INCREASED PRODUCTION

Simplification of Industry

The entire process of job standardization which has been described, complex as it may seem, is based on the fact that increased production with a lower unit cost is impossible unless modern large-scale industry is first simplified. It was stated in the first chapter that what is needed is a resimplification of industry. The simplicity of the original one-room shop where there were comparatively few operations performed by a few men and it was easy for the owner to know the details of the work is out of the question in a large industry. Aside from the complexity introduced by large-scale manufacturing and division of labor, there are still more important factors to deal with in the products of industry. All of which means that operations must be studied with the completeness of analysis described and that job standardization is necessary for the reason that simplification of a modern business involves the rediscovery of the relation existing between the many operations which are scattered over many departments and often over many mills.

Simplicity in industry, as in everything else, is the result of an infinite capacity for taking pains. At first it seems as if the elaborate and many-sided developments which simplification necessitates occasions still greater complexity. This is not the case. The study and development are complex, but they result in a definite set of rules for processing materials

and a definite method of putting the rules into practice. The result is simple because it removes doubt and makes for certainty in conducting the business. The apparent complexity due to highly ramified business is justified since it serves in the long run to reduce the inevitable complexity of modern industry. The process of job standardization is necessary in order to understand each operation in its relation to other operations. When the standards have been determined and applied, and not until then, the management is able to lay out each part of the work so that the business as a whole shall profit.

Phases of Scientific Management

Simplification of industry requires first of all the setting of standards. The method of setting and applying the standards has been outlined in the preceding chapters. The result of this process is that the methods of performance adapted to the characteristics of each operation become incorporated into shop traditions and performance.

Secondly, simplification requires that standards which have been determined shall be maintained. The necessity for this has already been discussed in Chapter XX. The charts shown in this chapter, however, would constantly show a marked decline in proficiency unless the standards could be maintained by a systematic managerial control. In other words the management must take the responsibility of planning the work from year to year, from month to month, and even from day to day in accordance with demands and with the standards set, and must see that these plans are followed.

The development of simplification in industry by setting and controlling standards has been called "scientific management."

Scientific management includes two major phases. One is standardization, the other is control. Since without function-

alization control could not be carried out, functionalization may, in a sense, be said to be a third phase of scientific management.

Scientific Management Defined

For the sake of clearness it might be well to repeat the definition given in Chapter I which condenses what has just been said in regard to scientific management.

The term "scientific management" is used to characterize that form of organization or procedure which is based on principles and laws established by a thorough investigation of manual and machine processes, materials, tools, equipment, and physical and psychological operating conditions; which standardizes operations and provides for instruction in new methods of execution; and which develops and maintains precise and automatic control, including the organization of the personnel, the processes, the materials, and the equipment in such functional co-operative relations as will utilize the highest technical skill available and capable of development in planning, supervising, and executing.

The establishment of standards to which this book is devoted, is only one part of the field covered by scientific management. The other part, equally important, is the development and maintenance of precise and automatic control. For the sake of greater clearness and brevity the existence of the second phase of scientific management has been assumed throughout the book. Nevertheless the connection between the two phases, and a few of their outstanding features, should be touched upon in order to give some idea of the way in which scientific management works in its attempt to simplify industry and increase production. A general idea of the subject as applied to manufacturing is all that can be given in a single chapter, but the fact that scientific management deals with all the aspects of business and that its principles can and

should be applied to every undertaking must on no account be forgotten.

In considering standardization in relation to control the subject is considered from a different and more generalized point of view than the one that has been taken in the book.

Standardization

In so far as management methods can be considered scientific in any sense of the word they must include standardization. The term standardization is used to cover the thorough investigation of all problems and conditions with the purpose of determining the laws which govern them. In industry a standard found by analysis is not final, but may be defined as the best devisable set-up which can be established economically at a particular time and under particular conditions. As the conditions change, this set-up is subjected to a reanalysis according to the laws found to govern the circumstances at the time, and rejected or adopted as it fails or succeeds in increasing the efficiency of performance. Thus the process of standardization is continuous. The method of operating, strange as it may seem, has not been studied and developed to the point that the standardization of the product has been studied and developed. In many cases when the term standardization is mentioned executives show no interest, for they immediately think of the standardization of their finished product which they have spent large sums of money to perfect in every minute detail. On the one hand, when it comes to standardization of methods of production they are content to follow methods which are the result of combinations of chance circumstances. Hence a complex body of practices develops, that bear no relation to the requirements of the work as a whole, and, because they are not based on laws, involve waste effort. The confusion of purpose of which they are the result ends in a general bewilderment which is manifest throughout the whole

process of production. Until their complexity is standardized there can be no simplicity of operation.

A pertinent illustration of a simple and effective way of applying carefully thought out principles is shown by the standards developed for the installation of Ford starters. There are two points brought out by this illustration—(1) the value of developing a standard method, and (2) the necessity of expressing such a standard clearly. Not only should the method to be followed be defined in detail, but the way in which the highly developed standards are to be expressed and put on record, should be continuously kept in mind. They must be clear and readily understandable so that new tentative standards can be measured against those already in force.

Installing Ford Starters

Until 1920 there was a great need for a starter for Ford cars, because the manufacturers had not included this item in their original equipment. As soon as the demand became great enough several manufacturers attempted to develop a self-starter that should be adapted to the car. One of the requirements was to make the attachment coincide with the bolts and connections already found in the Ford car, so that the man installing the starter would have to make as few changes as possible.

It was also necessary that the purchaser be able to install the starter himself. Otherwise it would hardly be possible to sell one to a man having no access to a well-organized garage. Moreover, wordy instructions such as might be used advantageously in a factory would in this connection be meaningless. After some study the chart shown in Figure 69 was devised and found to fulfil the requirements successfully. The chart takes up each part of the installation in detail, and the location of each part mentioned on the instruction card is marked on a corresponding diagram.

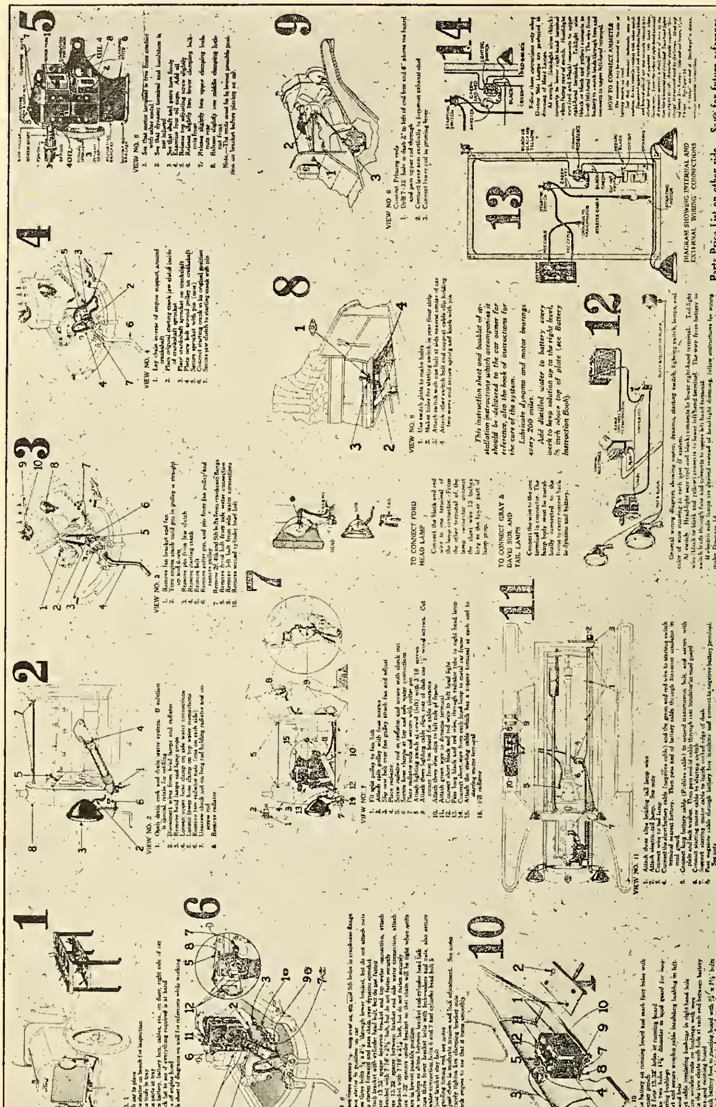


Figure 69. Diagram Directions for Installing a Ford Starter

Applying Standards to Construction Work

The way in which the most complex conditions may be simplified by the application of standardization was demonstrated on construction work. The general opinion at first was that, while it was possible to standardize industrial plants, because conditions in them were relatively stable with respect to machinery, equipment and organization, it would be impossible to standardize outside work, such as the construction of buildings, roads, and sewers. In outside work conditions change rapidly, so that they sometimes ceased to exist before standards could be set for them; often there is no space to keep materials on hand, freight delays even in the best of times prevent the obtaining of materials on time, labor is uncertain, and weather conditions affect materials as well as the amount of work which can be completed.

In spite of these difficulties it has been proved by actual accomplishment on all classes of work that scientific management applies as readily to construction work as to industrial work. The construction man realizes most forcibly one fact which to his mind seems unsurmountable, and that is that he has no actual operating organization when he starts any piece of work. When a particular piece of work is finished the organization which has been developed for that job dwindles to a comparatively few people who put on the finishing touches. The answer to the construction man's fears is that the analyst whom he retains to develop scientific management should be a practical, experienced man, able to take full responsibility for carrying on the work if the conditions require it. This is not necessary, however, in an industrial plant, for the analyst works with an organization who are actually producing, and his work, therefore, requires only a changing of conditions, so it is not of such great moment if some change is not put into effect by the factories' organization immediately upon the recommendation of the analyst.

The first construction job on which the principles of scientific management were applied more or less intensively was in connection with the construction of a large concrete building in 1910. In concrete-construction work the cost of the form work, which is merely a temporary skeleton in which to cast the concrete, is generally the determining factor as to whether the contractor will make a profit or sustain a loss. The first endeavors, therefore, were concentrated on this feature, and the other parts of the work were handled as they previously had been. The results on the first job were most gratifying as shown in the comparison of unit costs given:

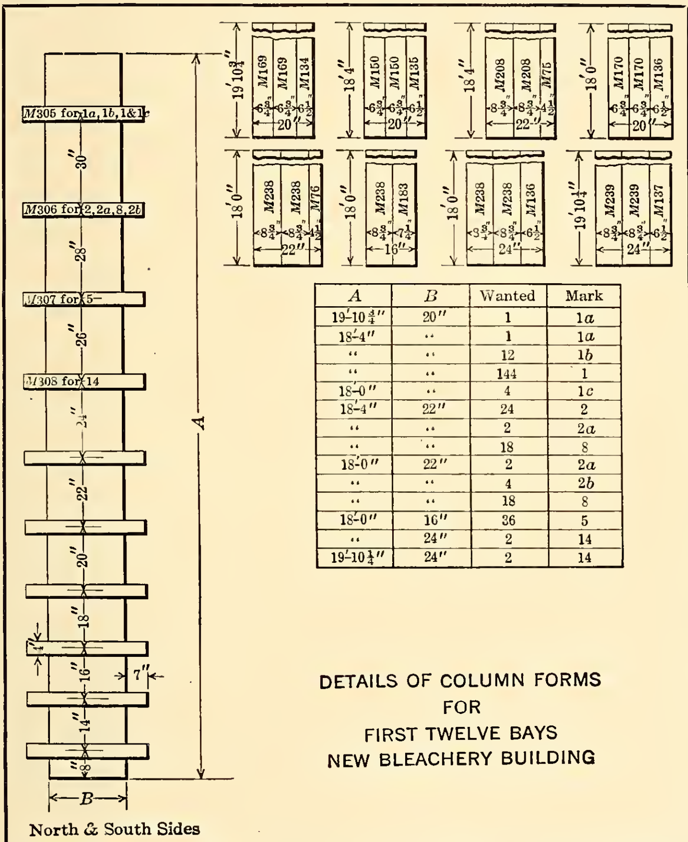
Operation	Cost of Labor under [1] Ordinary Methods	Cost of Labor under Scientific Methods
Making forms	2¼ cents per square foot	1¼ cents per square foot
Erect and strip forms	6 " " " "	4 " " " "

The work of the analyst started when the architect turned over the plans to the contractor. The first step was to have detailed sketches made of each form such as are shown in Figure 70. These sketches were complete, even to the determination of the dimensions of every piece of lumber. From these sketches the exact bill of lumber was taken off so that the most economical widths and lengths could be purchased. This arrangement eliminated the random purchase of lumber. The sketches were then used by the carpenters for sawing all the lumber to the exact length and for putting the forms together.

A method of marking the forms was worked out so that any ordinary unskilled laborer, under the direction of a gang boss, could tell the kind of form that was to be used by referring to a key plan of the building. In this way the workman could carry the material from the benches where the forms

[1] Figures based on wages existing prior to 1910. These figures include job expenses but not general overhead.

were made to the building site where it was put in place by the carpenters. This system eliminated the large loss caused by



A	B	Wanted	Mark
19'-10¾"	20"	1	1a
18'-4"	"	1	1a
"	"	12	1b
"	"	144	1
18'-0"	"	4	1c
18'-4"	22"	24	2
"	"	2	2a
"	"	18	8
18'-0"	22"	2	2a
"	"	4	2b
"	"	18	8
18'-0"	16"	36	5
"	24"	2	14
19'-10¼"	24"	2	14

Figure 70. Standardized Plan Used in the Construction of a Larger Concrete Bleachery

highly paid carpenters doing useless or avoidable work, such as hunting around for some particular form which the foreman said had been made but which no one seemed able to find. The standardizing of the work in this manner arouses interest in all

concerned and makes it possible to make the pay of the workmen commensurate with what they do and also eliminates the large loss due to the incompetence of workmen.

Standardization of construction work not only for large buildings but also for smaller units, such as frame dwellings, was developed from the procedure just outlined. During a period of two years small dwellings aggregating a total value of several million dollars were erected by these same methods.[2]

The result of the standardization of construction work was a simplification which made it possible for production to be increased and the cost of construction to be reduced.

Control

Control is the second of the major phases of scientific management.

The term "control" is used to describe the establishment of a mechanism by which the management takes over the detailed planning of production and regulates the flow of work. Control in industry necessitates exact knowledge as to the dates orders are to be processed and shipped, and the way in which they must be moved through the factory in order to keep the contract date. It necessitates information about the work ahead of each machine, the type and capacity of each machine, the raw materials required, and the number of employees needed to do the work, so that the work may be arranged in general and in detail, to meet customers' requirements and keep costs down to the minimum.

With the establishment of centralized control the duty of planning the movement of the product is no longer distributed among the foremen of the various departments through which the goods will pass before they are shipped as a finished product, but is centralized in the planning department.

·Appendix D for further details and results accomplished.

The planning department devotes its attention exclusively to correlating the work of departments and even of individuals. The detailed facts are placed at its disposal through standardization, so that this department is able to lay out the parts so that they will dovetail into the completed plan. Clerks carry out the routine of the plan formerly attended to by the foreman. In consequence the factory functions as a unit.

The contrary is true if a foreman alone does the planning. Even the capable foreman usually sees only his own needs, and "kicks" for repairs, for material, and for help until he gets them, although there may really be greater need for all these things in some other department. At its best, the result of lack of control is that one department inevitably perfects itself at the expense of the others. A manufacturing plant is similar to an army, and like an army, it needs its directing staff.

Relation of Planning to Process Department

The planning department and the process department are distinct, neither of which can exist for long without the intimate co-operation and understanding of the other. The planning department lays out the work in accordance with the standards which have been developed, it directs the processing of the product, and it follows up the results obtained by the process department. The process department directs the conversion of the raw materials into the finished product, and in so doing follows the established standards made out by the planning department. This work is modified only as the actual shop conditions and materials necessitate a change. When such a need occurs the process department immediately takes up the matter with the planning department so as to come to a mutual understanding on the way in which to handle the necessary changes. In case of disagreement between the two departments the case is submitted to the manager of manufacturing who settles the difficulty as an impartial judge.

ROUTE SHEET C FU .... ( ) ...... ( ) ( ) ....

Bays ....

F. O. No. ....

Furnish Order No.	F U Number	F O Number	Size and Weight	Finish	Amount	No. of Loads	Sheets Per Load
Grade Color Machine No. Hung AM PM Dry Hours Pull AM PM							

From M M .... MR Sheets ...... Spurs Poles
BAY NO. ....

Time	Bonus	Operation		F. O. Number	Load	Poles	Sheets	0
		Hang	M R H					
		"	"					
		"	"					
		"	"					
		"	"					
		"	"					
		"	"					
		"	"					
		Dry	M R D					
		Pull	M R U					
		"	"					
		"	"					
		Jog	M R J					
		"	"					
		"	"					

From M M .... MR Sheets ...... Spurs ...... Poles
BAY NO. ....

Time	Bonus	Operation	Symbol	F. D. Number	Load	Poles	Sheets	0
		Hang	M R H					
		"	"					
		"	"					
		"	"					
		"	"					
		"	"					
		"	"					
		"	"					
		Dry	M R D					
		Pull	M R U					
		"	"					
		"	"					
		Jog	M R J					
		"	"					
		"	"					

From M M .... MR Sheets ...... Spurs ...... Poles
BAY NO. ....

Time	Bonus	Operation	Symbol	F O. Number	Load	Poles	Sheets	0
		Hang	M R H					
		"	"					
		"	"					
		"	"					
		"	"					
		"	"					
		"	"					
		"	"					
		Dry	M R D					
		Pull	M R U					
		"	"					
		"	"					
		Jog	M R J					
		"	"					
		"	"					

SHEET WRITTEN		APPROVED		ROUTING		TIME STUDY				TICKETS, ORDERS WRITTEN						STARTED			FINISHED		
Day	Hour	Day	Hour	Day	Hour	Day	Hour	Day	Hour	Day	Hour	Day	Hour	Day	Hour	Month	Day	Year	Month	Day	Year

Figure 71. Regulation Route Sheet Used in Planning Department

The manufacturing orders are received by the planning department which sees that all the necessary specifications or data are on the order before accepting it. The orders which are O K are analyzed for the required raw materials, for the method of processing, for the way to split the order into jobs which are of a size convenient to manufacture and so on. Route sheets as shown in Figure 71 are then prepared and are used by the planning department, first, for making up the proper work such as time tickets, stores issues, and so forth, and second, for keeping track and directing the sequence of the operations required in the manufacturing of the product. The planning board as shown in Figure 72 is an office mechanism to facilitate carrying out the plans of the planning department.

On this planning board a duplicate of the workman's time ticket is posted under the machine or workman's name, so that the work being done by each machine or employee can be seen at a glance. The job ahead of each machine or workman are also posted, so as to facilitate providing work well in advance or shifting the workman to another operation or department where a scarcity of labor exists.

Proper Method of Planning Orders

A dearth or an abundance of work is not long apt to be the case in a factory of moderate size provided the executives are aware of the situation. Such a dearth or abundance, however, does exist in many large companies operating a number of factories all of which are directed from some one central office. The reason for their not realizing the seriousness of the actual condition in any particular factory is due to the immense volume of business done. In the case of a certain shoe company, for instance, if for any reason the raw materials did not show up for an order or if the particular lasts over which the shoe was built were not available when required, other orders

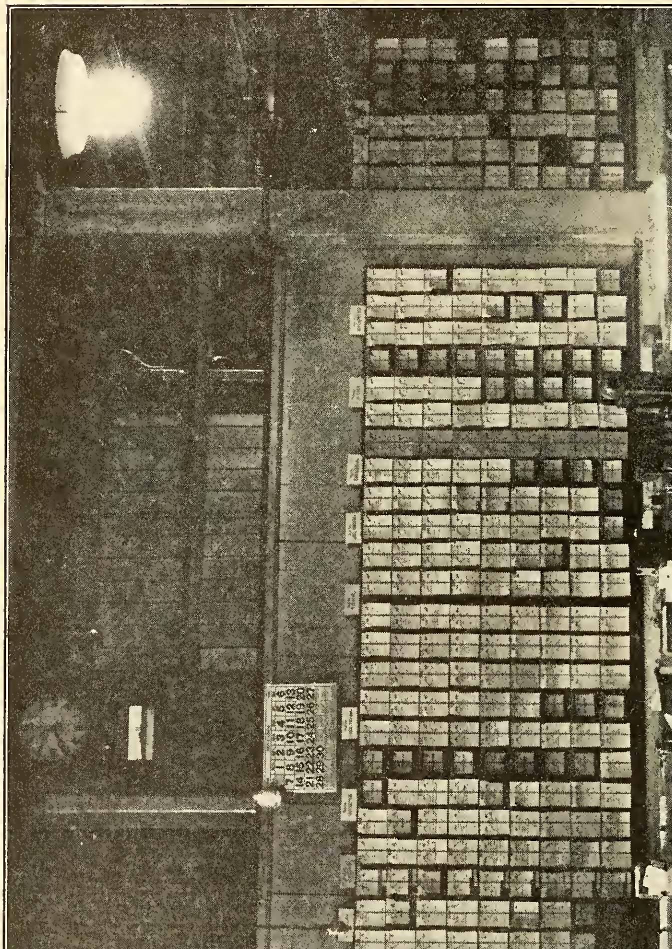
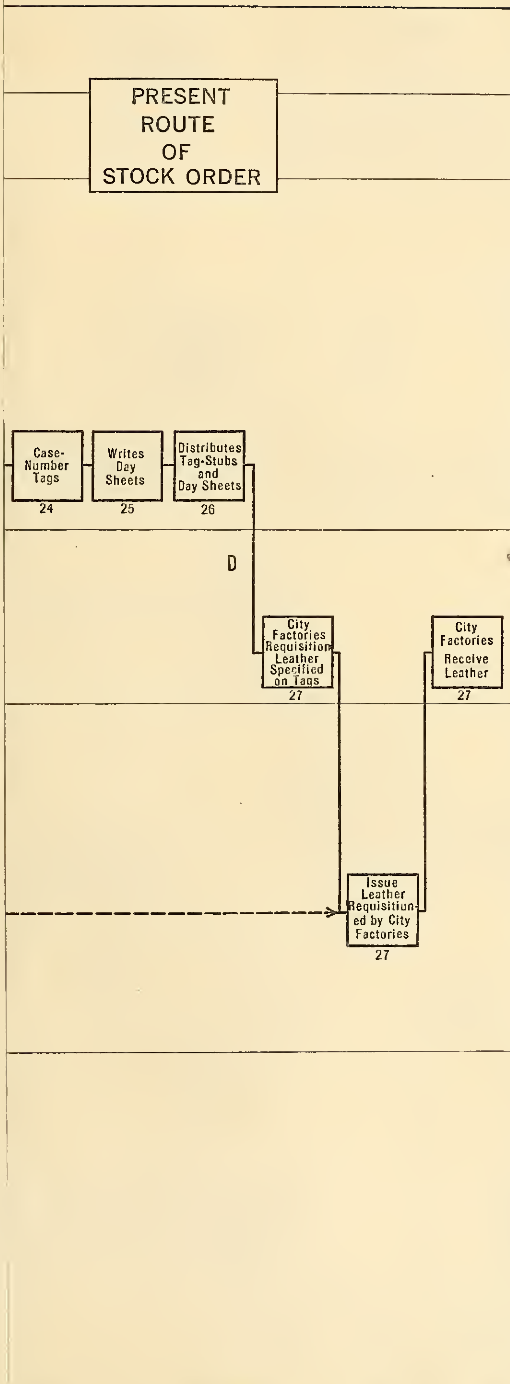


Figure 72. Regulation Planning Board


PRESENT ROUTE OF STOCK ORDER
Case-Number Tags
24
Writes Day Sheets
25
Distributes Tag-Stubs and Day Sheets
26
D
City Factories Requisition Leather Specified on Tags
27
City Factories Receive Leather
27
Issue Leather Requisitiun-ed by City Factories
27

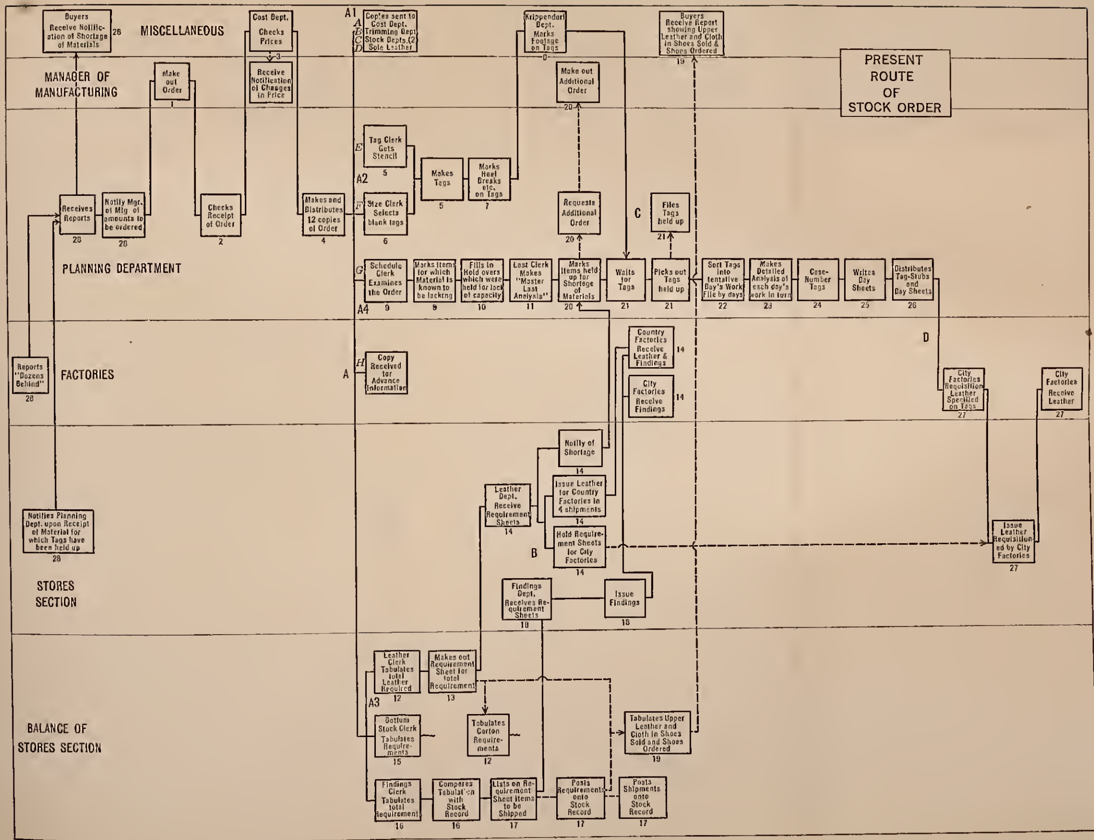
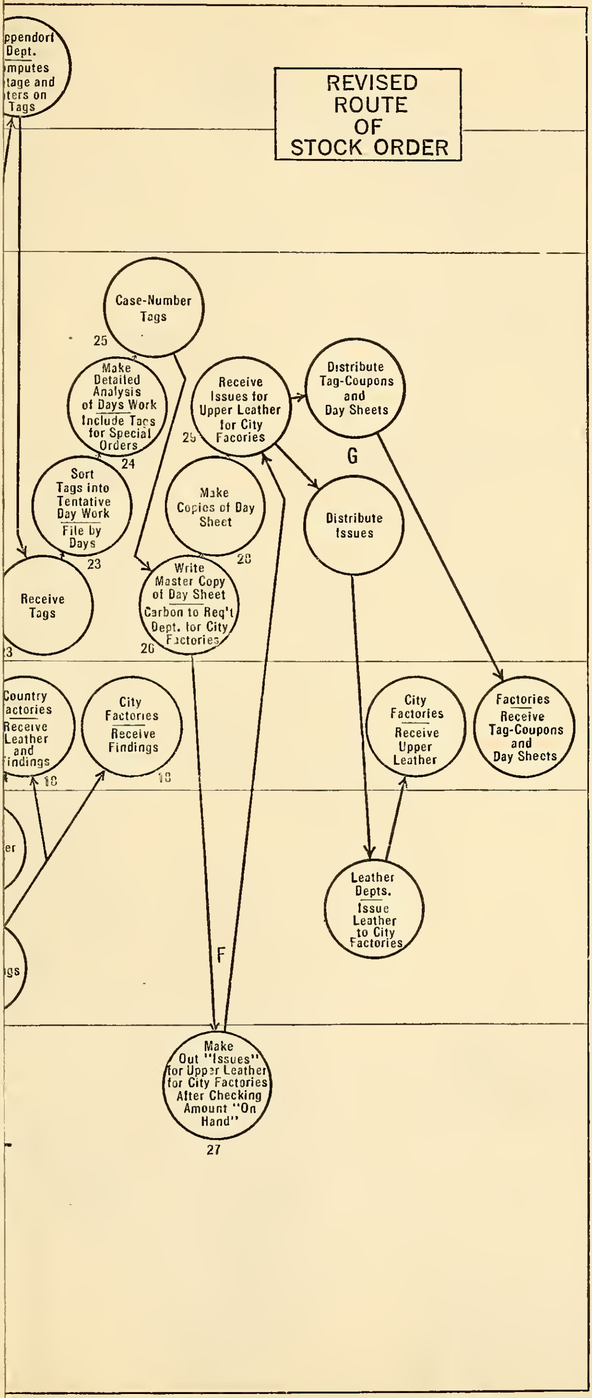


Figure 73. Route of Stock Orders before Analysis


REVISED ROUTE OF STOCK ORDER
ppendorf Dept. mputes tage and ters on Tags
Case-Number Tags
25
Make Detailed Analysis of Days Work
Include Tags for Special Orders
24
Receive Issues for Upper Leather for City Facories
29
Distribute Tag-Coupons and Day Sheets
G
Sort Tags into Tentative Day Work
File by Days
23
Make Copies of Day Sheet
28
Distribute Issues
Receive Tags
Write Master Copy of Day Sheet
Carbon to Req't Dept. for City Factories
26
Country actories
Receive Leather and indings
City Factories
Receive Findings
City Factories
Receive Upper Leather
Factories
Receive Tag-Coupons and Day Sheets
Leather Depts.
Issue Leather to City Factories
F
Make Out "Issues" for Upper Leather for City Factories After Checking Amount "On Hand"
27

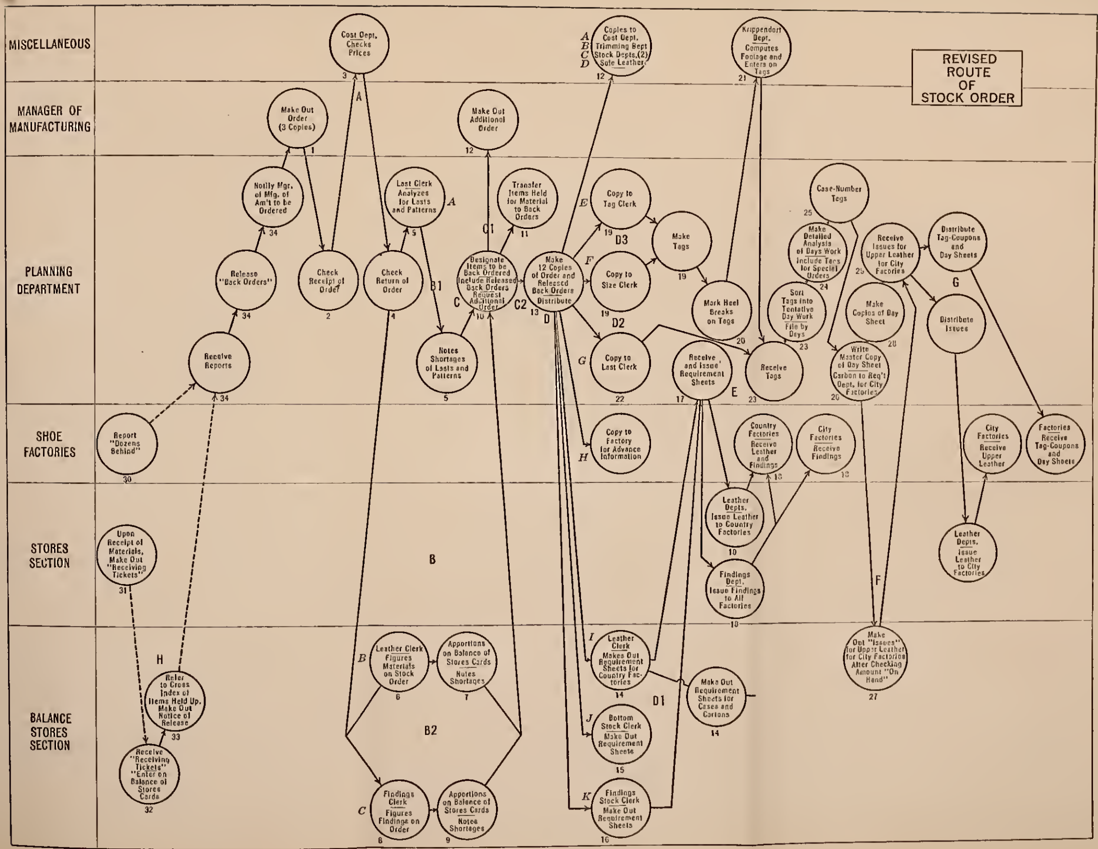


Figure 74. Route of Stock Orders after Analysis

scheduled for a later date were pushed ahead to keep the machines and workmen busy. An investigation of the method used by this shoe company in planning the work brought to light some astounding conditions. The company, of course, realized some of these conditions, but not their seriousness or extent. The big difficulty confronting the analyst in this case was how to present his findings to the company so that they could conceive readily the difference between their present method of planning the orders to be manufactured, against the method he proposed, which would eliminate these serious conditions. Since the problem of planning is quite involved, because of the many different grades and kinds of leather and findings that go into the different styles and grades of shoes to present it in the form of a report would mean nothing to most executives. After considerable study he devised the plan of charting the present and proposed routines. The chart of the present routine given in Figure 73 shows the whole story. The proposed routine as given in Figure 74 shows in comparison the advantages of the new plan.

Under the routine laid out in Figure 74, the copies of the manufacturing orders were not distributed broadcast, but only so many as were needed to determine from the stores records what materials were on hand. All copies of the orders made out at A went by way either of B 1 or B 2 and re-combined at C. This assured starting into the shop for manufacturing only those orders for which materials were actually available. This plan prevented congestion in the various departments as well as making possible to reduce greatly the quantity of leather and findings required in stores.

Under the routine existing before analysis, shown in Figure 73, there was no tie-in between the paper work in the office—marked A, C and D—and the various stores departments' activities—marked A, B and D—in getting out the materials on the orders and shipping them through the factory.

Functionalization

A necessary corollary to control is functionalization—that is, the systematic distribution of activities among various persons. As stated in Chapter I, control involves the assumption of responsibility by the management, and functionalization involves the delegation of this responsibility through the proper channels. Through functionalization the organization is developed so that it works as a unit in planning, supervising, and executing.

The model organization chart given in Chapter I shows the main functions of a scientifically managed business and the way in which they are distributed.

The department which has chief responsibility for standardization is the methods department. The department which has chief responsibility for the carrying out of control is the planning and control department. These two departments work in close relation, as already described, in order to get results without duplication of effort. Job standardization is dependent upon the maintenance of routine in the planning department and the process department because the employees cannot be expected to do the work in standard time unless conditions are maintained at standard.

Co-ordination of the Phases

It is by the co-ordination of these phases, standardization, control, and functionalization, that the industry is simplified to the point at which the work can be laid out with relation to the situation as a whole. Each phase is dependent on the others, and until all three are developed scientific management does not exist within the industry. It is by the development of industry through the co-ordination of the three that maximum production is obtained under existing human and mechanical conditions with the minimum cost and effort.

CHAPTER XXII

BALANCING MANUFACTURING AND SELLING ACTIVITIES

Returns Dependent upon Market Outlet

The large returns which result from job standardization are partly dependent upon the company's having orders for its merchandise. Increasing production is not of much advantage if the product cannot be sold. The lowered cost per unit produced is, however, a gain which may be utilized in either of two ways or, if the situation demands, in a combination of both—that is, it may be taken directly in the shape of a larger margin of profit or in the shape of a lower price, which also makes for larger profits because it stimulates demand. The profits from manufacturing are dependent upon the amount sold and the profits from selling are dependent upon economy of manufacturing.

To sell the product is the main function of the sales division just as to manufacture the product is the main function of the manufacturing division. Both functions are equally important to the business, for neither can exist without the other.

Although their mutual dependence is evident, it is not strange that each should think itself the important factor in the company's life and expect the other to realize this fact and to adjust its activities to meet the situation. The policy of the company on this point is due in many cases to the way in which the concern developed. If the financial head is at the head of the sales division he will naturally believe the sales end is the most important first, last, and always. If he is a prac-

tical manufacturer, he will probably believe the manufacturing end to be the most important. In reality, he is the one to recognize the equal importance of both and to encourage them to work together for the interest of the entire company.

Why then is there such a universal strife between these two mutually concerned divisions? The answer is that each is working in the dark as to what the other division is really doing, so that each one is ready to saddle the blame for any complaint or trouble that arises on the other division.

Necessity for Production Reports

The only way to prevent strife is for both the sales and manufacturing divisions to plan action on full and accurate reports of production conditions and the factory situation and the markets. Otherwise it is impossible for them both to get together in the right spirit and discuss their differences and mutual difficulties and to formulate policies incidentally making the work of both easier but designed first and foremost for the financial advantage of the entire company. Without the aid of reports based on accurate data, contact can end only in recrimination, ill-feeling, with the result that each will go its own way as before. It is, therefore, through scientific management that this strife is prevented, because the development of scientific management has separated the chaff from the wheat and brought out the essentials of the situation.

The proper use of the reports depends, of course, upon some systematic contact between representatives of the manufacturing division and the sales division. Even this first step, however, the provision for regular conference, is far from being a universal practice. One concern, having its divisions in three states—the sales division at the market center in New York; the manufacturing division in a small town where taxes are low, and the financial and secretarial divisions in a large center in still another state—went so far as to take the

stand that all correspondence and information between sales and manufacturing were to pass through the executive office. This decision served to divorce the two so completely that the sales division, having no idea of the needs of the manufacturing, burdened it with many unnecessary and expensive changes and sometimes even made promises which it afterward was obliged to confess to customers could not be filled.

Although contact helps to prevent either the sales or the manufacturing division from being at the mercy of the other, it does not, as has been pointed out, of itself co-ordinate their activities. Co-ordination of activities depends on accurate, dependable, and accessible information as to the factory situation. In order to understand the service to which such information must be put, the activities of the two divisions must be viewed from new angles.

Selling the Plant Capacity

The usual conception of the duty of the sales manager is the simple one already stated at the beginning of the chapter—i.e., it is the selling of the company product. From another point of view, however, his duties are not so simple. In selling the company product, he is really selling the plant capacity for making the product. What is meant by "selling plant capacity" may be explained by a reference to business conditions during the war. In a great many factories during this period the entire product of the factory was spoken for months in advance and the salesmen could not continue to sell, not because they lacked selling ability or because they could not stimulate demand, but because the plant capacity was already used up. In some cases this was due to the limited amount of equipment, but probably in more cases it was due to lack of labor, or of material on which to work—all three of which factors limit plant capacity. During the war many salesmen realized for the first time that by selling standard

lines for which material was already on hand, or on which the amount of labor was less, instead of booming the more easily selling specialties—in other words, by paying attention to manufacturing needs—they could in a sense actually increase the plant capacity. Furthermore, any unsold capacity or idle equipment is a drag on the rest of the plant. The total overhead, which remains the same, cannot be distributed over so many items, and therefore the cost per unit produced rises. In a competitive market, where the prices are practically fixed, loss is therefore sure to follow unsold capacity. Accordingly it may actually be cheaper to sell some line at what superficially appears a loss in order to avoid a greater loss from unsold capacity. It does not necessarily follow that when the largest volume of product is sold, the cost of manufacturing is least and the profits the largest. Rather is it true that when the entire plant capacity is sold, then the profits are greatest.

Reports on Plant Capacity

Looking at selling and manufacturing from this angle, it is clear that the reports on which plans are based should show the available plant capacity for each line produced. Such a report is given for each operation separately, and includes a statement of the amount and type of work that each type of machine has yet to do.

The reports are based on the two essentials of scientific management—job standardization and control. The information which they furnish has been collected by the methods department and is a result of the standards set by time study and job analysis. The application of this information in the factory, at any given time, is a part of the process of control. The material from which the reports are still further condensed is constantly used in the detailed planning done by the planning department. Little extra work is involved in drawing it off and presenting it to the sales manager.

When an order is received, the planning department, as stated, first breaks it into jobs that can be handled conveniently and then analyzes these into the processes or operations through which each job will pass. Each one of the operations is recorded on a separate card or slip. For instance, in a textile-mill the operation of winding warp, winding filling, making warp, drawing the warp through the reed, and weaving, would each be on a separate card. The standard time required to perform this operation with each variation in the character of the job would have been determined beforehand by job standardization. At this point the charts described in Chapter XX would be of service, because they show the proficiency of the factory and how much time (if any) to allow over and above the standard.

From these two sources—the standard time charts and the proficiency charts—the planning department is able to record on each operation card not only the time the job is to be started on the first operation, but also the time it can be expected to come out of that stage ready for the next operation. The variable factors of the order are also recorded on the card. A file is kept in the form of a visible index, which shows all the jobs or orders planned for the operation, and which are usually classed according to the special type of machine or labor necessitated by the variables of the job. This file shows the planning department which machines are to be free at a particular date. Because of this information the clerk can schedule the job to the particular machine fitted and at liberty to do the work. If the equipment of any type is overloaded or underloaded, the visible index, with its cards for each job, shows the condition at once.

Method of Making Report

Semiweekly or, if this means too much work, at least weekly, the planning superintendent can go over the visible

index and draw off from it a summary of the condition of work as regards the various operations, the dates on which machines of different types will be at liberty and the total hours of work ahead. He will also note the class of work on which the machines are occupied, since this will often mean that orders of the same class can be put in more easily—as, for example, if the loom has been producing a fine weave of cloth and is scheduled later for the same weave, it would be more economical to keep it going continuously on this weave.

The sales manager and the manager of manufacturing in conference will go over this summary of the available plant capacity so that they may utilize and sell the plant capacity to the best advantage.

Strengthening Sales Division Service

The service of the sales division to its customers is strengthened by the resulting co-ordination of activities. It is enabled to make definite promise to its customers because it has definite production information. Moreover it can reasonably count upon keeping its promises. Good service on deliveries is extremely important. Although a factory may have the best quality of goods to sell and the best force to sell them, failure to deliver at the specified time causes cancellations and loss of future sales. Giving this service depends on receiving accurate information from the manufacturing division as to shipment dates, and such accurate information can be determined as the result of detailed planning. The value to the customer in having a delivery date on which he can depend is very important. For instance, in an advertising campaign if the customer does not receive his printed matter on time, other contracts which he may have let for distributing it in certain issues of magazines may be upset. A case in point is that of a concern which made calendars. A calendar that reaches a client much after January 1 is about as inter-

esting as last week's newspaper. Yet in this particular concern the salesmen were always insisting on other orders being put in ahead, so that the calendars were never out on time. The manufacturing division accordingly sent reports to the sales division that gave a detailed statement as to the manufacturing situation, with the result that, although they made as many calendars as ever in 1920, for the first time in years they succeeded in getting all of them out before the middle of December.

When delays are unavoidable the sales manager is notified and is also informed of the cause, as well as given another date for production with which he may appease the customer. By this means he is relieved of the embarrassment of explaining to inquiring customers the reason for the non-appearance of their goods on the promised date.

The treatment of preference orders, which results from joint conferences on the manufacturing situation, is of great assistance to the sales manager. To put through every order as a "special" or a "rush" or even a "rush-rush" order means internal friction, broken promises, and dissatisfied customers. Nor is it easy, without definite figures, to convince the sales manager that any order to which he wishes to give preference must not displace work already laid out. The reports, however, show how the work is laid out, and whenever a request is made to give new work preference the manager of manufacturing can point out to the sales manager exactly what would be displaced and the resulting cost. Then the sales manager may decide as to which work is most important. A reputation for uniformly prompt delivery dates is a much better sales card than promises of special favors which often cannot be kept.

Increasing Economy of Manufacturing

This rational method of rushing orders only after consideration of the need is a great relief to the manufacturing division.

Without such a method it is constantly required to make changes in plans, speed up employees, and sometimes even to take the half-completed product from the machine in order to make way for preference work. The duty of the manufacturing division is to utilize to the full actual and potential plant capacity, and this it can do only by having the co-operation of the sales division.

With an organized method the manufacturing division is able to plan to handle orders more quickly. First of all the orders are reported to it as soon as they are received. Furthermore it is furnished with the desired date of delivery. The neglect of the sales division to specify the date often causes misunderstanding. In one case much hard feeling arose between a member of the sales division and the planning superintendent over the delay of a certain order. Investigation showed that the order had been sent into the factory with no time limit for delivery marked on it. From that time until three weeks later, when it had been put into process, over thirty "rush" orders came in and were given preference over the delayed order. Moreover with standardized methods the plans of the manager of manufacturing are not subject to so many and to such elaborate alterations if there is a conference relative to the suggested changes with the sales manager. At that time a report of the factory situation can be given to him in which the expense involved in any suggested change will be made clear. He is even able, from his knowledge of the date on which equipment will be free, to make requests to the sales manager for orders which can be made on that equipment.

By no means the least important of the benefits to both divisions is the establishment of friendly relations.

Estimating Cost of Orders

Another way in which the data compiled through job standardization should be used to balance the activities of the

manufacturing and selling divisions is in figuring estimates on the cost of orders. Data used for determining standards which the employees actually accomplish day in and day out may be put into tabular form for estimating purposes. In one case, where this was done at the solicitation of the sales division, it served as the first step in interesting that division in the work done by the manufacturing division. As a result the sales manager saw the value of changing some of the methods of figuring which had been in vogue for years and which were naturally based on general averages and were not so flexible or accurate as the data from the new source. Two great advantages accrue from figuring estimates on the data that is furnished by the manufacturing division and found by job standardization. The figures based on job standardization are absolutely dependable and accurate. The figures on which sales estimates are usually based have been reached by some one who at some time made a good guess. The method followed is to take all the machines as well as the jobs of a similar type and bring them under a single class, regardless of variations in the character of jobs. Then one estimate is struck which is used for all jobs of this class. As a result a large margin of profit has to be allowed over and above this indefinite figure, whereas with accurate figures based on careful study and showing the actual cost of variations in orders it is possible for the sales manager to give much closer estimates, often thereby underbidding competitors. Another advantage is that if the estimates are figured on a manufacturing basis a close check is furnished between estimated and actual cost of performance. It is accordingly easy to find where orders have been taken on at a loss and to avoid repeating the mistake.

Determining Company Policies

The reports given the sales division by the manufacturing division are not only valuable in making detailed plans from

day to day and from week to week, but in determining broad policies of the company. The sales and manufacturing managers together can work out measures suited to their mutual needs which they may submit to the general manager for approval. These include decisions as to maximum and minimum quantities of stock to be kept on hand, specialties to push, possibilities of development for new lines of product, and the advisability of standardizing the product, so as to reduce costly variations in style. Thus there are no longer two opposing points of view—the one, that the manufacturing division shall manufacture what the sales division can sell, and the other, that the sales division shall sell what the manufacturing division can manufacture. Instead the two are merged into one because of the company policy which is formulated to help the manufacturing division utilize the full plant capacity and to help the sales division sell the full plant capacity, with the single aim of the greatest economy and the largest profit to the business.

CHAPTER XXIII

JOB STANDARDIZATION AS A BASIS FOR LABOR MEDIATION

A "Solution" of Labor Troubles

Many manufacturers are afraid of job standardization as the cause of labor troubles. Though such an idea will be new to some people, the fact is that job standardization contributes largely toward the solution of labor troubles. Job standardization has really proved itself to be the best possible basis for improvement of industrial relations; for labor troubles, like every other trouble, can be solved only by analysis and study of the elements entering into the situation. It must be remembered, however, that there are no final solutions to the labor problem. All that can be done whether one likes it or not, is to meet that phase of the problem which concerns us most urgently at the moment

The Labor Situation

At present the situation is somewhat as follows: The employer who is paying for labor time suspects that what he is paying for is being delivered only in part; because he has no means of checking up these doubts he is unwilling to pay a cent more than he is forced into paying. Exactly the same is true of the employee. He suspects that he is being given underweight and so makes return in kind. It is like an exchange carried on in the dark, in which each one offers the other scamped goods for what he believes will prove on trial to be scamped goods. The exchange is carried on in equal ignorance, and in the end, as at the beginning, both parties remain as much in doubt as ever as to the justice of their bickerings.

The Three Necessities

To meet and overcome such a complication three things are necessary:

1. To get at the facts.
2. To establish channels of contact, so that both employer and employee are put in possession of such facts as are pertinent.
3. To find a third party whose position allows him to get at the facts and without prejudice present them to both sides.

Both the second and third points are dependent upon the first, that is, getting at the facts. As the situation now stands, at best only one side is informed on any one point. On the one hand the employees have more information as to the amount of work they are doing, on the other hand the employer has more information as to the situation from the financial point of view. Neither can be said to have exact data even on one of these two factors. Since both factors, the output and the financial condition, are involved in almost all questions at issue, both sides are able only to guess at the factor on which they are uninformed. The detail facts on the work are in reality as unknown to both as is the situation as a whole. In any wage dispute between the employer and the employees there are two main issues. The first is the obvious one, the amount of remuneration to be paid. The second, inextricably mixed up with the first in the mind of the man on the street, is the amount to be produced. While it is inevitable that the two will be confused as long as no one knows the facts about either, it is quite possible to get the facts at least on the second issue, i.e., the amount to be produced. The method of getting these facts has been described as the work of job standardization.

The first issue, the amount to be paid, has not been dealt with scientifically in the same way. There is still room for

opinion, judgment and compromise. The only hope, however, of reaching a settlement which has any claim to justice and any elements of permanence is to base opinion, judgment and compromise upon the information found concerning the amount to be produced. Thus the first great essential in the industrial situation is dependent upon job standardization.

Channels of Contact

No settlement making for co-operation can be realized unless both sides have the necessary information. This is true not only in the case of an actual dispute, but also in the daily conduct of the industry.

Capital must know, not by rule of thumb, but with scientific finality, the facts that are indispensable to a just administering of its part of the obligation. Labor on its side must be as thoroughly informed of the facts which it needs to know and for the lack of which knowledge it falls back on accusations, recriminations and permanent suspicion. The situation will be met only when both sides have that complete assurance which comes from a knowledge that rock-bottom facts are available to all who are vitally concerned.

The employer with little more than his financial idea about the situation cannot overcome the difficulty. Neither can the best energies of the employee be enlisted unless he knows that the facts he has are trustworthy. Any plan, if it is not executed in such a way as to enlist the energies of everyone concerned will surely be a partial failure and perhaps a total one. If the employees are convinced or are suspicious that job standardization is being imposed on them in order to take away their jobs or to make machines of them, or if the foreman and other executives feels that their rights are being encroached upon, the plan becomes a liability instead of being an asset. In order to win their co-operation a full explanation should be given to all the members of the organization, from the superintendent to

the workmen. One result of making the whole organization a party to the work is that the facts are put in the possession of both sides.

Mutual co-operation is brought about and maintained by the establishment of channels of contact. These may be informal or formal. Both kinds have been tried by employers, in some cases with considerable success in overcoming suspicion and hostility on the part of the employees. Neither method can be used as an agency for intelligent co-operation, however, unless there is first some intelligent basis for co-operation in place of mutual ignorance.

Informal Contact

Most of the informal channels by which information is brought quickly to the employees are, through necessity, provided by the employer, and thus are dependent upon the degree of intelligence and the progressive attitude which the employer assumes toward the situation. Sometimes courses are instituted for the employees in which they are taught some of the principles and fundamentals of business in general and their business in particular. The usual channel of this sort is a purely personal one. A man in the management in whom the employees have faith and who works closely with them can talk with them and give any information desired. Such a man brings the employees into contact with the ideas of the management and the management into contact with the ideas of the employees.

Formal Contact

In using the formal channels of contact the employer again usually takes the initiative; but if properly planned these formal channels function more or less independently of him. They provide a mechanism that gives the employees representation in the councils of the management. This mechanism may

have the form of the shop committee or works councils (which may or may not be unionized) and the plan, modeled on the lines of the United States Government, sometimes termed "industrial democracy." Under the former and less elaborate plan the employees elect representatives who meet in conference with representatives of the employers, to thresh out grievances, wages, conditions, bonus, and manufacturing problems. Special committees and sub-committees are often appointed or elected to attend to special problems.

Under the United States government plan, the house of representatives is elected by the employees, a certain number from each department according to the size, the senate is made up of executives, while the cabinet is composed of officers of the company and those in supreme control. This plan is open to considerable modification in practice.

Employee Representation Plan

The United States government plan has been adapted by the Printz-Biederman Company to fit its conditions. In place of the senate, for instance, a planning board composed of representatives of each of the major divisions of the plant acts for the management. The planning board has proved capable of acting more quickly, decisively, and efficiently than the senate.

The members of the house of representatives are elected from the departments, one to every 20 employees. There are from 30 to 40 members, representing about 600 employees. Regular meetings of the house are held on company time, once a week between 10 and 11 o'clock. An important provision, which should always be in effect where there is to be any real "democracy," is that the house of representatives is entitled to hold meetings *alone*. The cabinet, planning board, and betterment committee may be present in the house of representative only by permission.

"The function of this House of Representatives shall be to study and recommend such action as shall be concerned with the production of good coats and suits at the lowest possible cost; the payment of highest profits, salaries and wages consistent with competitive ability and betterment of social and physical conditions among the people of the Printz-Biederman Company."

Regular committees elected by the house of representatives are: a betterment committee, a wage committee, and a board of reviews.

The betterment committee looks after all complaints covering social and physical conditions of the employees.

The wage committee determines, in agreement with the management, what minimum base rates shall be paid and, when such changes have not been satisfactorily adjusted by the foreman or superintendents, refers individual applicants for changes in rates to the management.

The board of reviews is composed of two members of the management, chosen by it, and two representatives of the employees chosen by the house of representatives. Its function is to consider all cases of discharge referred to it. If the testimony proves that the applicant has violated a rule affecting the standards of discipline or standards of production, or that he has been dishonest, he cannot be reinstated. Otherwise the findings of the board are final.

A provision is made that in case the house of representatives and the management cannot come to an agreement on some question and have exhausted every means of settlement provided for in the constitution, they shall choose a person satisfactory to both to arbitrate the question.

The plan, the management states: ". . . is designed to give our workers an opportunity to legislate together with the management on all matters connected with their work, such as wages, hours, and conditions of employment."

Such means and methods do not of themselves provide either side with the essential facts, but, the facts being known, they do make for co-operation.

Mediation

The third step in establishing co-operation is the employment of a third person who can consider the facts without personal bias or prejudice in favor of either side. This man must have the confidence of both sides.

On various occasions, indeed, capital and labor have been willing to make use of conciliation and arbitration, both of which involved submitting differences to an authorized board or person selected from the outside. The difference between conciliation and arbitration is that in the case of conciliation, no decision reached is binding on the disputants, whereas in the case of arbitration the decision has a binding force. Boards of conciliation and arbitration were organized during the war by the local, state and federal authorities to prevent losses resulting from long-drawn-out struggles. Prominent individuals were even asked to pass upon the merits of an issue. Now that the war is over employers and employees are as far apart as they dare be in refusing to arbitrate. In spite of the cost they prefer to fight out the issue, for the reason that they both have suffered from the defects of arbitration as commonly employed.

Defects of Customary Arbitration

The reason that conciliation and arbitration have proved inadequate is that the position of the third party has been a false one. In the first place he is usually called in to arbitrate at a date when the bickerings have already reached the point of open conflict and neither side is in a mood to compromise. In the second place he has no way of being informed on the actual situation. To examine the problem thoroughly would

take months, or perhaps years, and no one is willing to wait so long, as was demonstrated in the outlaw strikes by the railroad brotherhoods in 1920. The arbitrator is moreover obliged to sift and weigh such evidence as he is given, which means that he must be an exceptional man. He usually has no way of checking the evidence, because he rarely knows the difficulties of the particular industry and plan, but only the difficulties of industry in general. He is, accordingly, obliged to make a superficial decision, which may, or may not, reach the sore spots. If his decision is not final, and he is acting only as a conciliator, the fact that both sides are thoroughly aroused before he is called in makes it unlikely that the side to which his findings appear less favorable will be ruled by it. Even if the agreement provides that his decision is final, any decision not based on the facts of the situation will serve only to postpone open conflict for the time being. While conciliation and arbitration cannot be considered as anything more than makeshifts and are in no sense substitutes for co-operation, they do at least make clear this much: the necessity for a third party, acceptable to both capital and labor, who can mediate their difficulties by bringing out the facts.

The Analyst as Mediator

The logical third party for mediation to call upon is the one who is able to present the facts on which decision must be based. That person is the analyst. In a sense he is the industrial mediator, working in conjunction with those immediately concerned.

There have been, however, arguments against the use of such a mediator, for capital has been accused, and, in some cases rightly, of abusing technical information submitted to it by experts in its employ. Capital itself, moreover, has felt that the information furnished by the industrial engineer was in many cases, largely a mass of involved detail.

Now, however, that the technique of sciences is being used increasingly, the qualifications of the analyst are becoming more and more clear.

He is, first of all possessed of the chief requisite needed by both sides; a complete and detailed knowledge of the facts. Through job standardization he knows exactly what amount the average skilled employee can be expected to produce; he is also informed on the market rates and the relative requirements of the various operations.

Unlike the ordinary arbitrator, he is not obliged to make a special investigation in order to ascertain the facts, because he already has them in hand. At a time when delay is unfortunate, such a resource diminishes losses to employees in wages by shortening the period of open conflict. Being in possession of the facts, he is able to furnish them before the clash comes, and, as a result, he is often in a position to act as conciliator.

The type of man needed in job standardization is also the type of man fitted to undertake the duties of mediator. He must be respected by employers and employees, because his work is checked up by both. He must be ready at all times to listen to both sides, and he must have shown himself to be open-minded.

Neutrality of Analyst

Under some conditions an objection may be raised by the employees to the analyst in the rôle of mediator, in that he is not neutral. This is often true if he is employed directly by the concern and his job is thus dependent on the fact of his standing in well with the employer. Where the analyst is the representative of a firm of consulting engineers in industrial management, this objection has not been raised, even though the firm is retained by the management. The firm, however, must be one with a reputation over many years of

practice of fair dealings with both capital and labor in order to be accepted by them as a neutral third party.

In one or two instances the analyst has actually been jointly employed.

The analyst who is acting as mediator carries on his usual duties in the factory in the same way as has been described. In the course of his daily routine he acquires the information which is so essential to his duties as mediator. The fact that he is finding a just balance between the various operations, that he is helping to standardize the work in such a way that he is making it possible for the employer to give additional pay for increased production resulting from standardized efforts, reduces the likelihood of trouble over wages and conditions of work. Whenever there is any dissatisfaction or dispute over the base rates, or over any rates, or over payments for any operation, the employer or employee may call on him for information.

In the case of a serious dispute the duties of the analyst include, in addition to furnishing information, a suggestion for settlement based on his knowledge of the facts at issue.

If the analyst can reveal to each side the point of view of the other side, and at the same time can place before both all the information concerning the question at issue, he succeeds in casting some light on what has hitherto been a struggle in the dark. Both capital and labor are thus placed in a position in which they are able and willing to consider the settlement he proposes, or any modification of a settlement which they can agree upon, on the basis of mutual understanding in the place of mutual suspicion.

Examples of Analyst as Mediator

An interesting example of the work of the analyst as mediator occurred in 1916 in connection with the New York dress and waist industry where job standardization was intro-

duced to replace an economically devastating warfare. The late Robert G. Valentine, serving as director of a board of protocol standards succeeded in having job standardization introduced, so that decisions could be based on exact findings.

The important problem before the board concerned wages. An hourly wage of 35 cents for the average employee had been agreed upon, but the work was almost entirely on a piece-rate basis, and the relation between thousands of styles of garments, the different kinds of materials used, the unskilled and the skilled employee, and the various degrees of skill called for by different divisions of the labor of garment making, were all points left to the board. Piece rates had formerly been set by means of an elaborate system of shop tests, which resulted in innumerable disputes and in rates which were disproportionate. In one instance, after analysis, the manager admitted the insufficiency of the rate and raised it, the raise being retroactive to the agreement. In another instance the union, convinced that the rate was too high, paid the difference between the sum the manufacturer had paid in wages, at $4.20 a dozen waists, and the sum he should have paid at the revised rate of $3.85 a dozen waists, the sum amounting to several hundred dollars. A union member was one of the "assistants" working under the direction of the analyst.

On this spirit of fairness it was possible for the representatives of the manufacturers and of the unions to meet with the director of the board of protocol standards, recognize the definite conclusions drawn from job standardization, and agree upon piece rates on the basis of the data furnished.

The building up of operations from the elements was like the building up of thousands of words from the twenty-six letters of the alphabet, and created a language in which the workers and manufacturers could talk intelligently.

In this case collective bargaining, on the one hand, was not done away with, and on the other, time study and job analysis

and its results were not forced upon the employees by the management. The basic wage rate was still a matter for collective bargaining. But the original bargain once struck along broad lines, the details of the settlement were left to job standardization, carried out under the supervision and with the co-operation of both sides. Although in this particular case further action was stopped, it was not from the inadequacy of job standardization but from a series of outside and highly conflicting interests.

It seems not unlikely that among the industrial changes in the future will be the use of job standardization in individual manufacturing plants, with labor co-operating with the management and sharing the control, much along the lines developed by Mr. Valentine.

Another arrangement somewhat resembling the union agreement made at the instigation of Mr. Valentine is that of a committee for the introduction of job standardization to help avoid labor complications. This committee, organized in a printing concern, consists of the labor manager, who represents the company, one of the union workmen, who represents the shop, and the analyst, who represents the neutral party by being the representative of an outside industrial engineering firm. These three handle the problems that come up, because they have the backing of both sides, and because all who are interested know what is going on and the nature of the object to be attained.

Employee representation, although not including the principle of collective bargaining, provides for arrangements along similar lines. While it would be most unlikely that the employees would have sufficient solidarity to pool their resources and combine to employ experts jointly with the management, there is provided, nevertheless, an opportunity for the analyst to act in the rôle of mediator. Because the employees have every chance to make their voice heard in the

conduct of the industry as well as every chance of knowing that the management is fair, they are ready even in disputed cases to accept the decisions of the analyst.

Conclusion

Democratic organizations, whatever the type, under which both sides are attempting to deal together with industrial problems, are the ideal bodies to undertake job standardization. They are endeavoring to minimize the industrial struggle, but they are still in the dark. By furnishing the facts on the very problems with which they are wrestling, job standardization makes it possible to avoid the waste and misery of industrial conflict. At the same time, by adding to the joint effectiveness of labor and capital in production, it increases the total fund available for wages and profit.

APPENDIX A

REELING AND INSPECTING COATED PAPER

Description of Operation

As shown in Figure 75, the paper to be reeled, trimmed on both edges, and inspected, comes in large rolls which are placed on the bottom of the machine. The loose end is then threaded over guide rolls and circular knives at the top and back of the machine, and brought forward to the winding shaft at the top and front of the machine. In the finished roll there are usually 2,000 sheets 20 inches long (3,333 linear feet) with an average width of 26 inches. As the paper is wound on the finished roll, the operator tears out and throws away imperfect paper and glues the two good ends together in what is termed a splice. The finished rolls are taken from the machines, wrapped and delivered to the packing room.

The job analysis indicated the following possibilities for improvements:

1. Increase in production from machines due to improved methods saving time and labor with a bonus incentive and graphical competitive accomplishment charts.
2. Saving in waste of material on machines due to training employees and making bonus earned partly dependent on care in taking out waste.
3. Saving in waste of time on machines caused by absence of operators, break-downs, and daily and weekly cleaning of machines. This saving would be gained by better planning, mechanical inspection, and by doing the cleaning out of hours.

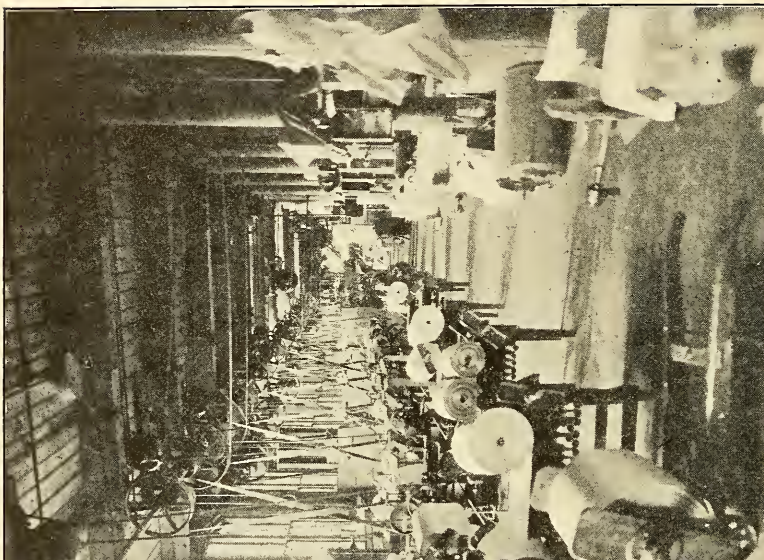


Figure 75. Manner of Putting Rolls of Paper into Reeling Machine

4. Improved quality by machine operators due to training and to making bonus earned dependent on care in taking out bad paper, making good splices, and trimming.
5. Saving in waste of material and time on auxiliary operations handling rolls going to and from the machines, and in wrapping and trucking the rolls out of the department. This saving would be gained by developing two special trucks, one for feed rolls and one for finished rolls, changing the planning and control routine, and by putting the auxiliary men on bonus.
6. Saving of departmental clerk due to changing the planning and control routine and to keeping the lots of paper separate by means of the new trucks.

Changes in Methods and Equipment

Under the unstandardized conditions the machines were shut down while the operator, if a girl, waited for a man, frequently the operator of another machine, to take the shaft with the finished roll from the machine, pull the shaft out of the roll, put an empty strawboard core on the shaft, and replace it in the machine. Of the two collars used on the finished roll-shaft to guide the paper (see Figure 75) the left-hand one was never clamped in final position until several feet of paper had been wound on the core to indicate the exact width of the sheet.

The adjustment when made necessitated a special shut down. These delays were cut down by providing two extra finished roll shafts for each machine and a man for each three machines to do all the work, except actual lifting from and onto the machine, while the machines were running. The collar adjustment was made before the shaft was put on the machine by providing measuring sticks equal in length to the width of the paper.

Similarly, it was the custom to change the feed roll by taking out the shaft with the empty core, pulling off the core, putting on a new roll and finally putting the shaft and roll back on the machine. After the roll was in the machine a heavy paper wrapper was taken off. These delays were cut down by providing an extra shaft so that a roll stood ready to go into the machine at all times. The wrapper was removed ahead of time and later, when the special trucks (see Figure 76) were available for keeping the paper off the floor, it was discontinued altogether.

A considerable improvement in making splices was effected. Formerly a strip of bad paper was torn or cut out, leaving uneven ends. Before splicing both ends were carefully folded, creased and torn off to leave a smooth square end. Glue was then "painted" on one end, the other end lapped over and rubbed down. The girls were taught to cut out the bad paper by cutting with one stroke of the knife at each end in such a way as to leave the end good enough for a splice. Tests proved also that the right amount of glue could be applied by drawing the brush once across the paper, and that the rubbing could be reduced to one firm stroke of the hand.

Formerly a paper band was wrapped around each finished roll, glued, and certain information written on it by the employees before the roll was taken from the machines. Gummed labels, furnished with information partly filled in by the planning department, were substituted. Incidentally this device cut down clerical work formerly done by the departmental clerk. Information concerning the rolls handled was formerly written on three separate tickets by the employee. Two of these were cut out and the information formerly posted on three is put on one.

Chairs with a special pigeon-hole and rack for the girls were devised which enabled them to store samples, tags and strawboard cores in the chair instead of walking across an

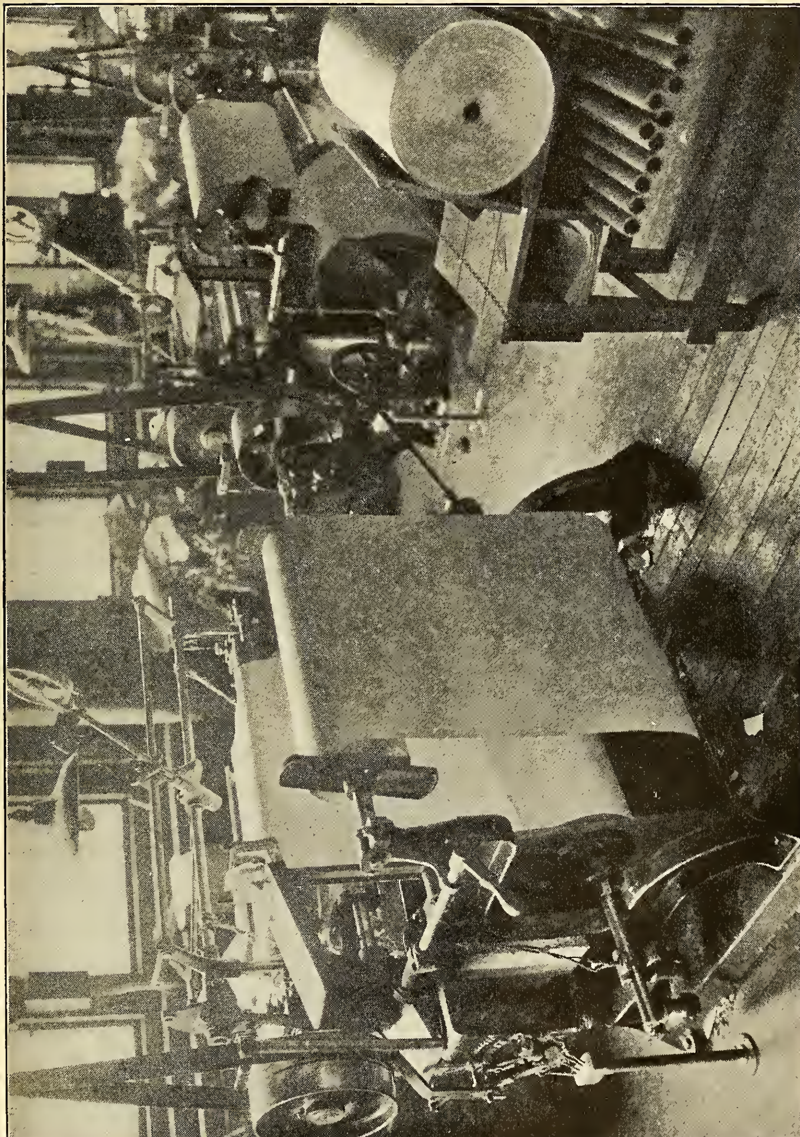


Figure 76. Special Truck for Keeping Paper Off Floor

aisle where they were placed formerly. These chairs were also provided with backs which were of some help to the girls.

The truck on which the finished rolls are placed, shown in Figure 77, was designed to save rehandling of rolls through keeping each customer's orders together. In this way each order worked upon can be handled and delivered to the packer separately, thus avoiding sorting and checking of rolls. The truckers had previously gone about the room with a smaller truck selecting rolls here and there according to customer's orders and placing them on the floor convenient to the sealers who put a heavy wrapping paper around each roll and sealed this so as to keep the roll of paper from getting damaged. The sealers sealed the rolls and put them back on the floor. Later a trucker would pick them up and after they had been checked by a clerk they were taken to the packing room. With the new truck the 5 rolls are moved directly from the machine to the wrapper and left on the truck. The wrapper seals them and puts them on a truck holding two 5-roll units, 10 rolls in all, on the opposite side of his bench. This truckload is then moved to the packer who signs for them—which means that the rolls have been received by the packing room. The work of the sealer and trucker is cut down and clerical checking is entirely eliminated.

The feed-roll truck shown in Figure 77 was designed to receive the feed roll as it is dropped out of the machine. It was also designed for carrying the roll to the reeling department; and to contain the roll while it was waiting to be reeled. Furthermore it was designed so that it might be pushed directly under the reeling machines in such a way that the roll (with the shaft previously put in place) could be pushed over the edge and dropped into place with the shafts resting in the bearings. Through the use of this truck, time is saved for the tender because he no longer has to rehandle rolls on the ordinary baggage truck—in fact, his work with the new truck is

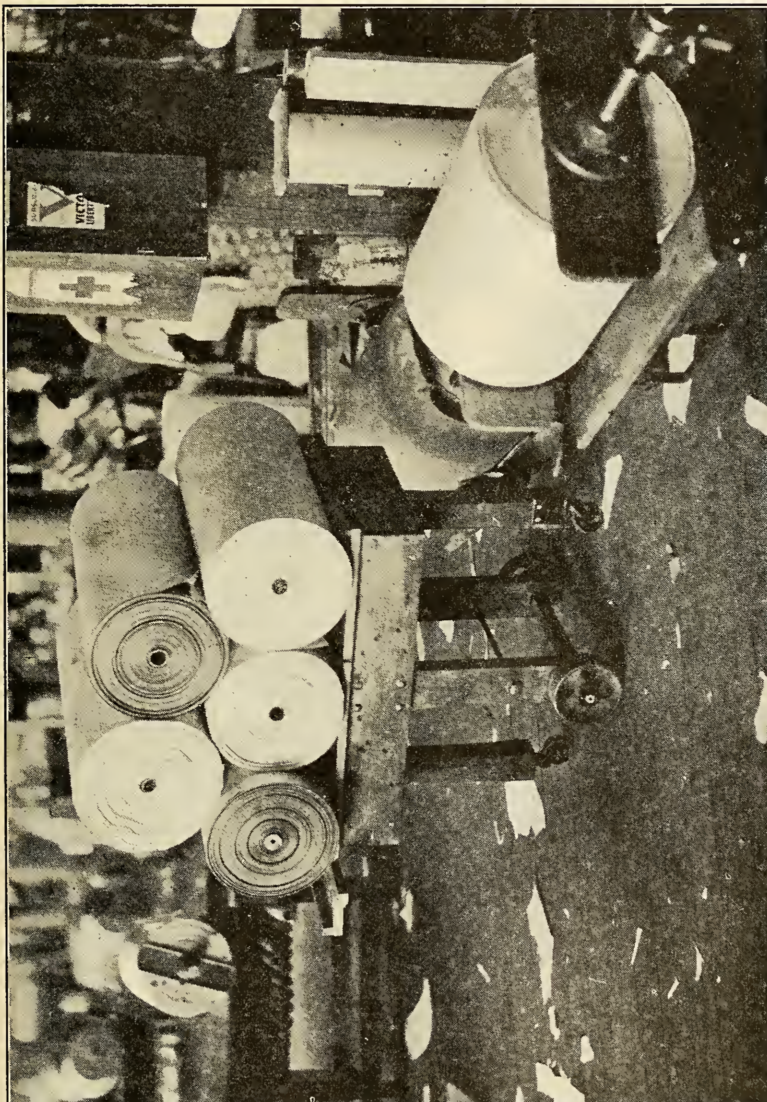


Figure 77. Standardized Trucks on which Finished Rolls Are Placed

much easier. Considerable waste is prevented because each roll is left on trucks which are wide and long enough to prevent collisions between the roll and other rolls on trucks. Such a precaution lessens the risk of tearing the edges of the paper.

A variable speed motor designed under the direction of the company superintendent and master mechanic was an especially ingenious device. The machine was orginally driven by a belt to the shaft carrying the finished roll. This gave the shaft a uniform speed in revolutions per minute, so, of course, the speed of the paper in feet per minute increased as the size of the finished roll increased in diameter from 2 to 12 inches. Under the new plan the handle of the rheostat which controls the speed of the motor is connected with the sheet counter that rides on the finished roll. As the roll gets larger the counter is lifted higher and higher and the rheostat handle is pushed along over the resistance contacts in such a way that the revolutions per minute of the finished roll-shaft vary, whereas the linear feet of paper reeled per minute is practically uniform from the start to finish. The speed selected is the maximum reached with the old equipment.

The effect of the increased speed on production was interesting. Records indicated that the mere installation of the motor showed no increase in output as a result of the 59.1 per cent increase in speed. This condition was entirely logical. In the first place, the actual running time of the machines was only 25 per cent—the balance of 75 per cent being used for changing rolls and other operations. In the second place, the new speed was greater than formerly so that bad paper was wound into the finished roll before the girl, who was not accustomed to this greater speed, could stop the machine. The extra time needed to unwind and wind up by hand, off-set the increase in speed. When, however, the standardized bonus system was introduced for the machine operators, the proportion of running time was increased, and the money incentive,

based on work turned out, kept the girls wide enough awake to stop the machine promptly when bad paper came along. The method of stopping was much improved also.

Of the other improvements, the spring clip for the counter enables the operator, when splicing or changing rolls, to push the counter out of the way with one hand instead of using both hands as it formerly was necessary to do when the counter was hung upon a hook that swung from the ceiling.

A simple device was also developed for threading the paper into the machine. A curved piece of galvanized iron was placed on the back of the machine in such a way that the girl, in threading the paper through the machine, pushed the paper from her under the revolving knives into the semi-circle-shaped curve of the sheet of iron. The end of the paper then automatically reversed its direction and came forward over the knives to the front of the machine. Formerly it had been necessary to push the paper back under the knives and then walk to the back of the machine and push it forward over the knives.

Estimated Increase in Output

After several months of time-study work, an estimate of the increase in output on the reeling machines was made and the total itemized and credited to the various causes as follows:

	Per Cent of Old Annual Output
Tender to change rolls and extra shafts:	
Feed Roll	8.75
Finished Roll	15.46
Elimination of wrapper on feed roll due to special truck	6.65
Preparation of glue and oiling machines	8.57
Ends split for splices instead of folded and torn	5.52

Cleaning after hours by janitor	11.18
Band on finished roll replaced by gummed label	4.87
Labels prepared in planning department	0.74
Revised job ticket	1.09
Reduction in samples due to standardization	5.95
Samples and tags stored in operators' bench instead of across an aisle	1.02
Variable speed motor giving a uniform speed 59.1% greater than previous average speed	8.67
Decreased down time due to better planning	12.10
Spring clip for counter instead of hook	1.14
Automatic return for threading paper through the machine	0.97
Total annual increase due to improved methods	92.68
Increase due to extra effort of the operators and to elimination of miscellaneous delays	71.32
Total annual increase in output	164.0%

It was necessary to itemize the saving in this way because the proposed changes in methods were radical in some cases and appeared to the foreman and company officials to involve a possible deterioration in quality. Under day-work conditions these changes would undoubtedly have encouraged slackness and a deterioration in quality, but under bonus conditions with each employee paid practically in proportion to her interest in her work the changes could be made with no danger whatever to quality. The changes listed were actually made.

Outline of Plan of Bonus Payments

In laying out a method of paying bonuses it was necessary to pay strictly in proportion to the effort of the employee. The effort of the employee, however, was in no sense measured by the amount of paper used or finished. It was necessary to take into account the effort of stopping the machine, taking

ESTIMATE OF YEARLY SAVINGS DUE TO BONUS WORK

Comparative departmental costs under day work and bonus work handling volumes of business varying from "present output" (average for 1918 and 1919) to maximum capacity under bonus work.

Item	Day Work Costs: Present Output 4,200 rms. per week (average for 1918 and 1919)	50% increase in volume of business (1 shift and overtime)	100% increase in volume of business (2 shifts)	150% increase in volume of business (2 shifts and overtime)	Bonus Work Costs: Present output 100% eff. 4,200 rms. per week	50% increase in volume of business 100% eff.	100% increase in volume of business 95% eff.	150% increase in volume of business 95% eff.
	(1)	(2)	(3)	(4)	(5) 5.6 reels	(6) 8.4 reels	(7) 11.2 reels	(8) 14 reels
Cost of Labor:								
Girls operating machines	$ 8,500	$ 8,500	$17,000	$17,000	$ 6,190	$ 9,280	$11,400	$14,300
Men assisting girls	5,640	16,215	11,280	21,855			4,500	6,000
Bundlers	2,255	3,660	4,510	5,915	1,500	3,000	1,250	2,000
Wastemen	984	1,600	1,968	2,584	1,250	1,250	1,500	1,500
Truckers	1,235	2,000	2,470	3,235	1,500	1,500	1,500	1,500
Movemen	1,200	1,950	2,400	3,150	1,190	1,190	1,190	1,190
Clerks or inspectors	850	1,380	1,700	2,230	2,080	2,080	2,080	2,080
Tenders	1,870	2,800	3,740	4,670	4,500	6,000	9,000	10,500
Total labor	$22,534	$38,105	$45,068	$60,639	$18,210	$24,300	$32,420	$39,070
Cost of Overhead:								
Power	$3,500	5,200	7,000	8,700	2,500	3,000	3,500	4,000
Fixed L & H	1,200	1,400	1,600	1,800	1,100	1,200	1,200	1,200
General Finish	8,400	9,000	9,500	10,000	8,400	9,000	9,500	10,000
Total overhead	$13,100	$15,600	$18,100	$20,500	$12,000	$13,200	$14,200	$15,200
Rate-setter					450	450	450	450
Total cost	$35,634	$53,705	$63,168	$81,139	$30,660	$37,950	$47,070	$54,720
Net Saving [Day Work Costs shown in columns (1) to (4) minus bonus work costs shown in columns (5) to (8)]					$ 4,974	$15,755	$16,098	$26,419
Machine hours	31,250	46,825	62,500	78,075	13,104	19,658	26,210	32,765
Machine hour rate including labor	$ 1.14	$1.15	$1.01	$1.04	$2.34	$1.93	$1.80	$1.67
Unit cost per ream	$0.142	$0.144	$0.126	$0.13	$0.120	$0.099	$0.092	$0.086

Note: These cost figures are relatively correct but have been slightly altered to avoid showing exact condition. The figures on savings are correct for a certain wage rate.

Figure 78. Table Showing Savings Effected under Standardizing Bonus System

out waste, making splices, and matching samples whenever the paper was not continuously in the feed roll.

Figure 78 shows the many savings under various conditions due to this bonus installation. Columns (1), (2), (3), and (4) show the cost for labor plus overhead with the work being done under the conditions before job standardization was undertaken. Columns (5), (6), (7), and (8) show the cost after job analysis has been completed. Columns (1) and (5), (2) and (6), (3) and (7), and (4) and (8) are figured on the same quantity of output. The figured savings per year vary from $4,974, with the output corresponding to the average produced between 1918 and 1919, to $26,419, if the full output of the machines can be disposed of by the sales department. The unit cost per ream of 500 sheets of paper with the machines running full is $.086 against $.12 with a small output.

APPENDIX B

ECONOMIES OBTAINED IN PAPER-MAKING

The operation of a paper machine involves great expense and presupposes considerable skill on the part of the operator. Because of the skill required and the effect of even slight variations on the finished paper that result from mishandling the machine, executives of paper-mills are loath to inaugurate any standardizing processes. In one mill, however, the finishing processes were standardized, and in this way was made possible the studying of the paper-making machinery itself.

It was found that the increase in production of a paper machine might be accomplished in three ways:

1. By increasing the speed of the machine.
2. By making the sheet of paper on the machine the greatest possible width, or, as it is technically called, increasing the deckle width to the maximum.
3. By reducing the number and length of shut downs through better planning of the orders.

In the case under consideration, to establish correct speed standards past records were tabulated, showing the speed of the paper machine for each kind of paper run on the machines. It was found that with the same "furnish" (combination of raw materials from which the paper is made), the speeds of the machine, on orders run at different times, would vary as much as 50 per cent. This variation in speed was caused sometimes by variation in the stock, and particularly by lack of uniformity in the raw materials.

As a result of this study and through the partial standardization of the beating of the stock, definite speeds for certain

grades of paper were established for each furnish. The standard speeds of the paper machines which were established for one grade of paper are shown in Figure 79. The small circles in the figure show the actual speeds at which the machine was run for different weights of paper before the standards were set. The full lines indicate the speeds determined by time study. The speed of the machine varies with the weight of

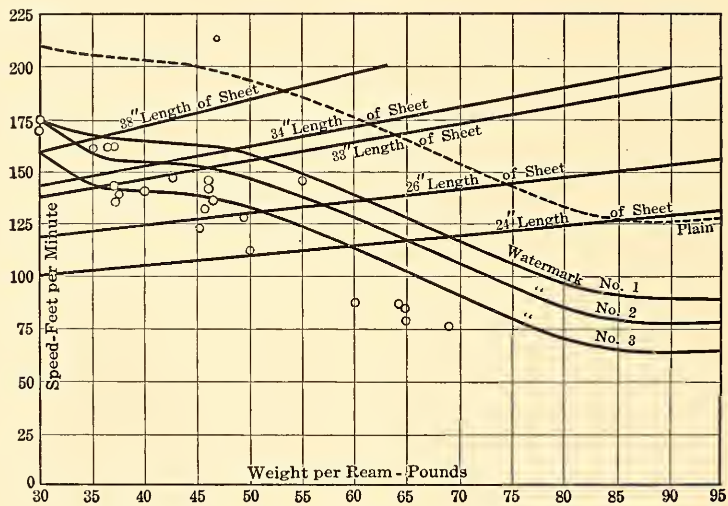


Figure 79. Standard Speeds for One Grade of Paper

the paper, as is to be expected, because the heavier the paper, the slower the machine will have to run in order to get a uniform product off the machine. The study also showed that a paper without a water mark could be run at very much faster speed than a paper which had to have a water mark; also that different kinds of water marks required different speeds.

Many high-grade writing papers are cut out into sheets at the finishing end of the paper machine when they have to be put through the dry lofts in order to get the best quality of

finished paper. The studies showed that the paper which was cut into a 24-inch length could not be run as fast on a machine as a paper cut thirty-eight inches long. This is shown in the figure by the straight lines intercepting the curved lines.

An illustration of determining the speed of the machine for this grade of paper, as given in Figure 79, will clarify what may seem to the casual observer quite complicated.

Let us assume, for instance, that we wish to determine the speed of the paper machine for stock which weighs 50 pounds per ream (paper not water-marked—in other words "plain") and which is to be cut 34 inches long. The speed of the machine can be determined directly by following the vertical line at the point marked 50 on the lower line of the figure to the straight line marked 34 inches, as this is the length of the sheet. The speed of the machine therefore is seen to be 165 feet per minute. If the sheet had been cut 38 inches long, the speed could have been increased to 182 feet. Again, if the paper had not been cut in sheets but had been taken off on a roll, the speed of the machine could have been increased to 192 feet per minute.

The increase in speed of the paper machine varied with the various grades of paper. In some cases at the start it was found that some of the speeds were increased as much as 30 per cent, and in other cases even more, over the average of the old speeds. These increases are considerable when one realizes that the quality factor is a very large part of the making of paper.

APPENDIX C

STANDARD REQUIREMENTS AND QUALITY BONUS

All work which is standardized through job standardization involves a combination of production and quality standards. Usually the production standards are stressed, with quality taken care of by fixing definite percentage or by definite amounts of money by which, in the event that certain specified quality standards are not obtained, the production bonus is decreased or not allowed at all. Occasionally, however, the analyst is faced with an exceptional case, as is cited here. In this instance the attaining of quality standards are the big factors, instead of the production factor, as in ordinary cases. The production factor is taken care of by reducing the number of employees to a point where reasonably diligent efforts are necessary to get out the day's work.

The problem of standardization in this case was unique in that it was not a question of producing in a given time the same product of a certain quantity, that must have a certain finish which determines the quality, it was a case in which it was necessary to take pulp colors that had been purchased from different color manufacturers and received in barrels and obtain from them batches of color, which would contain the same color value. These batches of color are used in the process of coating paper stock and a few minutes reflection will show the necessity of having the color uniform in shade so that when one lot is compared with another there shall be no disparity. There are many variables involved in this problem, such as the varying shades of the paper itself, the amount

of foreign matter in the color, as well as other ingredients used in the coating, and so on. These, however, are within certain limits and not as serious as the factor of pulp colors.

The pulp colors when they came from the manufacturer showed such varying percentages of moisture that 100 pounds used for one mixture of color might have the same color value as 130 pounds used for the next mixture. Naturally it was difficult to retain any one shade, especially when several different pulps were mixed to give the shade required.

The standards to this process were arrived at by carrying out a series of tests to determine the proper method of measuring, mixing, and handling the colors which were used in the orders actually being turned out by the mill and not done as an experimental proposition. In this way it was possible to determine the discrepancies and losses of all kinds under each particular condition. This required painstaking work on the part of everybody connected with the investigation. The instructions, standards, and allowances as determined by the analyst are appended.

Schedule A

Bonus Standards on Mixing Pulps

1. Mixing Requirements for Pulps in Cans

Every can, except Steel Blue Eakins, must be mixed once a day with a paddle.

Every can from which pulp is to be sent downstairs on an order must be thoroughly mixed with hand paddle before material is taken out.

From 10 to 15 cans will be tested or inspected daily.

Cans tested must come within 100 per cent of the amount of water in the can at the start. Thus, 49 to 51 as against 50 per cent standard. A special mixing will be allowed before sampling for this test.

Cans inspected must show no pulp deposited on the bottom or sides of the can, no lumps and no water on top. This in-

spection will be made shortly after the can is mixed in the morning, or an order from the Color Room Planning Department is filled.

2. Bonus for Mixing of Pulps in Cans

One can found with pulp deposits on bottom or sides, or in lumps, or found with water on top, or found to have 1 per cent more or less moisture than was originally in the can after the laboratory test	Allow 60 per cent of daily bonus
Two cans found not up to standard	Allow 30 per cent of daily bonus
Three cans found not up to standard	Allow none of the daily bonus for mixing pulps

Instruction for Mixing Pulps

1. Pulp Mixing Is Easy

If you get a smooth mix free from all lumps on the Brighton Mixer.

If you get a prompt moisture test, add water accurately, and mix at once.

If you keep the pulp in condition by mixing thoroughly once a day.

If you scrape all pulp from the sides and bottom of the can before trying to mix.

Detail Instructions

2. Mixing Pulp from Barrels on Brighton Mixer

Fill can from barrel. Put in only enough pulp to permit careful paddle mixing, without slopping, after water is added.

Mix until smooth and free from all lumps, and until bottom corner is free from all deposits.

Take sample from laboratory before Brighton Mixer is shut down. Do not skim the sample from the top but dip down into the pulp.

Put sample into jar, cover tightly, and take to laboratory without delay.

Scrape pulp from mixer paddles into can, remove can and cover tightly.

Wash paddles in a pail of water.

3. Adding Water after Moisture Test

Laboratory will report water to the nearest ¼ pound.

Weigh water accurately and add to can without slopping.

Mix water into pulp at once, using hand paddles.

4. Daily Mixing of Pulps

Mix every pulp with hand paddle once a day as early in the morning as possible.

5. Mixing before Filling Orders

Get scales and dish ready and adjust the weights for tare before starting to mix. Get the dipper ready to use.

Mix the pulp thoroughly with the paddle.

Change from paddle to dipper quickly and weigh out the material. Put in the last few pounds slowly and get an accurate weight but lose no time on the bulk of the pulp.

Fill the dipper each time by dipping well down into the can and sweeping the dipper through the can from one side to the other.

Avoid spilling any pulp.

If the dish must be filled a second time, as is the case for orders over fifty pounds, tare the dish a second time.

Mix the pulp with the dipper before taking out the second lot.

This care is necessary because the pulp starts to settle as soon as mixing is stopped. If the mixing is done first and a delay follows while the scales and dish are brought from across the room, etc., the material taken out will not be thoroughly mixed. In all cases if mixing is done and a delay follows, mix again before trying to fill an order.

6. Special Mixing for a Check Moisture Test

Check moisture tests will be made from time to time to determine if the bonus is earned. These tests will be made on pulp in cans partly used up or on pulp sent downstairs to fill an order.

In all cases the pulp from which the sample is to be taken will be given a special mixing in the Monitor.

7. Method of Handling Paddle while Mixing

Hold the paddle nearly perpendicular with right hand on top of the handle, and left hand about two feet below the top.

Scrape the side of the can, holding the paddle perpendicular.

Scrape the bottom of the can by pushing the paddle straight back and forth until the entire bottom is clean.

Scrape the side of the can once more, making a special effort to clean out the lower corner.

Stir the pulp. Start the pulp swirling around the can in a clockwise motion, then change suddenly and stir in the opposite direction. Cover all parts of the can.

Test the results of mixing by scraping the bottom and sides of the can to see if thick material collects on the end of the paddle, and by lifting a mass of pulp out on the paddle blade and letting it fall slowly back into the can. The pulp should be smooth and free from lumps and uniform in all parts of the can.

8. Brighton Mixer vs. Hand Paddle

The Brighton Mixer may be used in place of the wooden paddle at any time provided it does not slow down the work.

The Brighton Mixer must be used on Steel Blue Eakins.

Quality Requirements for Handling and Weighing Pulps

A daily physical inventory will be taken on a number of cans of pulp, selected at random. The amount in the can must equal the amount started minus the orders filled within the following limits:

A loss of 6 ounces for each day the can has been in the Monitor (this allows for the daily mixing).

A loss of 6 ounces for each order taken from the can (this allows for the mixing before each order).

A loss of 4 ounces for each order taken from the can.

Example: A can of 350 pounds is filled on Monday. On Thursday it is inventoried for a bonus test. Orders have been filled as following during the 4 days: 50, 65, 40, 100, 10, and 5 pounds, or a total of 270 pounds. How much should then be left in the can?

Answer: The allowable loss on 4 daily mixings is 4×6 ounces = $1\frac{1}{2}$ pounds. The allowable loss on 6 mixings be-

fore filling orders is 6×6 ounces $= 2\frac{1}{4}$ pounds. The allowable loss on weighing 6 orders is 6×4 ounces $= 1\frac{1}{2}$ pounds. The total allowable loss is $1\frac{1}{2}$ plus $2\frac{1}{4}$ plus $1\frac{1}{2} = 5\frac{1}{4}$ pounds. The amount in the can should range between a maximum of 80 pounds and a minimum of $74\frac{3}{4}$ pounds.

Bonus Payments

For Handling and Weighing Pulps

In case the cans weighed for the daily tests do not come within the limits specified by the quality requirements, the full bonus is not earned for the day.

For only 1 can outside the limits specified, allow 75 per cent of the daily bonus.

For 2 cans outside the limits specified, allow 40 per cent of the daily bonus.

For 3 cans outside the limits specified, allow none of the daily bonus.

Instructions for Weighing and Handling Pulps To Avoid Losses and Discrepancies

To earn the bonus paid for accurate and careful handling for all pulps it is necessary to:

1. Avoid losses of all kinds.
2. Weigh all material accurately.

1. Method of Avoiding Losses

Don't fill pulp cans so full that you cannot stir without slopping after the water is added.

Wipe the Brighton Mixer blades clean after grinding and see that all pulp gets back into the can (do not rinse the blades into pulp cans; rinse into pail of water).

Put the sample for moisture test into a covered carton and avoid spilling. Scrape all pulp, sticking to the knives or spoon used for sampling, back into the can.

Put back into the can the sample sent to the laboratory. Nearly all of it will be returned. Scrape the carton clean and be sure to get this pulp into the can it originally came from.

Avoid spilling pulp or water when mixing in water ordered by laboratory, when mixing can daily or before filling orders.

Scrape the wooden paddle clean after mixing, by scraping on edge of can.

Avoid spilling pulp when weighing orders.

2. Method of Weighing Accurately So That the Actual Weight in the Can Will Be the Weight Shown on the Planning Department Books

Get the weight right to start with.

All cans will be weighed for tare and a list posted in the Monitor.

Weigh every can of pulp after grinding.

See that the carton of pulp for the laboratory moisture test is placed on the scales with the can.

Enter the weight on the bin tag and on the mixing ticket.

Weigh accurately the water ordered after the moisture test.

Enter the weight of water on the bin tag and on the mixing ticket.

3. The Weight of Pulp Plus Water Must Be Completely Accounted for If the Bonus Is to Be Earned

Weigh each order accurately.

See that the scales are clean.

Weigh the small dish for tare.

Set the weight accurately.

Adjust the pulp in the dish until the scale beam balances exactly.

If more than one dishful is needed, tare the dish before each weighing.

Avoid mistakes due to shifting of weights by vibration; check the readings on the beam after the weighing is done.

Report information to planning department clearly and accurately.

Show can numbers from which pulp is taken.

If an order is split between two cans, show the can numbers and the amount taken from each.

If pulp is transferred from one can to another, be sure that the bin tags show what actually happened, and that the planning department is fully informed.

Do the work as rapidly as possible but take time enough to do it right.

If you are in doubt what to do under these instructions, take the matter up with Mr. Jones.

APPENDIX D

CONSTRUCTING HOMES UNDER SCIENTIFIC MANAGEMENT METHODS

In applying scientific management principles to the construction of homes a peculiar problem was presented: each unit or home was comparatively small and the work required but a few men from different trades. Another peculiarity was that the homes were scattered over a large area. Some of them were in adjoining lots, others were a mile or more apart. Despite these facts the analyst was able to apply the same principles he had used in the construction of large units, such as concrete buildings in all kinds of industrial plants.

In order to show the comparison between work done by day labor and by scientific management, several houses were selected where the work had been done by day labor under a very competent foreman who had in fact formerly subcontracted for his work at low costs. An equal number was selected to exemplify the scientific method. A comparison of the relative cost showed that the cost in the two houses built by day labor was as follows:

1. Setting of first-floor joists cost 78 per cent more than with time work with bonus.
2. Erecting first-floor curtain walls cost 26 per cent more than with time work with bonus.
3. Erecting second-floor curtain walls cost 16 per cent more than with time work with bonus.
4. Erecting first-floor subfloor cost 54 per cent more than with time work with bonus.
5. Erecting second-floor subfloor cost 59 per cent more than with time work with bonus.

In the work of common laborers, such as trenching and backfilling for sewers and water pipe, large reductions in cost were also effected. For example, in a case where the digging was of an exceptionally hard and varied character, because of the stiff, tenacious clay, the following results were obtained:

Operation	Unit Cost No Bonus Work	Unit Cost With Partial Bonus Work
Excavation	48.0 cents per cu. yd.	34.8 cents per cu. yd.
Pipelaying	11.1 cents per lin. ft.	4.5 cents per lin. ft.
Backfilling	34.6 cents per cu. yd.	10.6 cents per cu. yd.

These results were obtained by:

1. Economical design and layout of construction operations.
2. Laying out in advance the method of handling the work to reduce to a minimum the quantity of construction material.
3. Selection of the best tools and materials.
4. Arranging the processes to simplify the work, and teaching the men how to do each process in the best way.
5. Designating in advance the amount of work to be done by each man.
6. Giving the men a definite money incentive to encourage them to do a large day's work.
7. Eliminating the time ordinarily lost by workmen, in waiting for orders, waiting for foreman to lay out the work, waiting for materials, looking up tools, using improper tools.

The general principles that may be applied to construction operations are similar to those which have proved so satisfactory in shop management. As Mr. Taylor so ably states:

Under scientific management the "initiative" of the workmen (that is, their hard work, their good-will, and their ingenuity) is obtained with absolute uniformity and to a greater extent than is possible under the old system; and in addition to this improvement on the part of the men, the managers assume new burdens, new duties, and responsibilities never dreamed of in the past. The managers assume, for instance, the burden of gathering together all of the traditional knowledge which in the past has been possessed by the workmen and then of classifying, tabulating, and reducing this knowledge to rules, laws, and formulae which are immensely helpful to the workmen in doing their daily work.

Mr. Taylor groups this and three other types of duties which involve new and responsible burdens for the management under four heads as follows:

First. They develop a science for each element of a man's work, which replaces the old rule-of-thumb method.

Second. They scientifically select and then train, teach and develop the workman, whereas in the past he chose his own work and trained himself as best he could.

Third. They heartily co-operate with the men so as to insure all of the work being done in accordance with the principles of the science which has been developed.

Fourth. There is an almost equal division of the work and the responsibility between the management and the workmen. The management take over all work for which they are better fitted than the workmen, while in the past almost all of the work and the greater part of the responsibility were thrown upon the men.

It is this combination of the initiative of the workmen, coupled with the new types of work done by the management, that makes scientific management so much more efficient than the old plan.[1]

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[1] F. W. Taylor, The Principles o: Scientific Management, 1911, page 36.

APPENDIX E

SAVINGS MADE THROUGH STANDARDIZATION OF PULP MANUFACTURE

The pulp mill is a unique illustration showing that the establishment of standards of quality of manufactured pulp results in a large saving in the materials used as well as a large increase in production. This is shown in a concise way in Figure 80 where the production and quantity of materials used previous to 1914 are treated as units, this being the period prior to the starting of the standardization work.

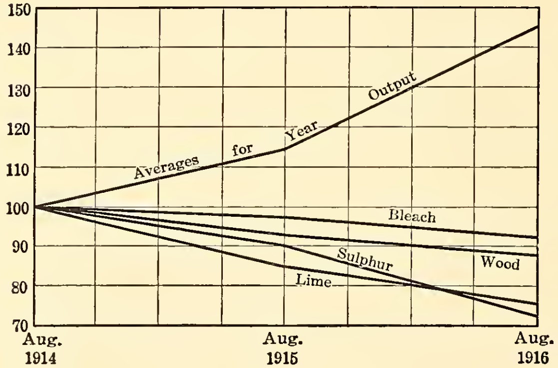

Figure 80. Ratio Showing Decrease in Material Used and Increase in Output due to Installation of Scientific Methods in a Pulp Mill

Processes of Sulphite-Pulp Manufacture

To bring out more clearly the development in the pulp mill we will describe very briefly the process of making the sulphite pulp.

Logs ranging in diameter from 4 to 12 inches, or even larger, and averaging about 6 inches, come to the mill in 4-

foot lengths, and after being cut in two are barked, the bad knots removed and the pieces run through a chipper which produces chips about ½ inch in length. From the chipper they are raised to bins over the digesters. The steel digesters, about 14 feet in diameter and 38 feet high, lined with acid-proof lining, are filled with the chips, which are then covered with bisulphite of lime liquor produced by a combination of sulphur gas and slaked lime. After cooking for a period of from 8 to 14 hours, varying partly with the character of material and partly with the judgment of the cook, the pulp is blown off into large tanks, being then of a consistency something like coarse, wet, short-fibered cotton. This pulp is washed in various ways, screened, bleached, and run either into wet sheets or rolls or in some cases pumped to the paper-mill.

As usually made the pulp is extremely variable, consequently no two cooks have exactly the same quality. The purpose of the standardization was to overcome this lack of uniformity and, as a consequence, to increase the production.

Quality of Wood

Studies were made of the characteristics of different kinds of wood, such as slabs, green wood, dry wood, peeled versus barked, and so on, to determine the relative economy and the quality of the pulp turned out. It was found through this investigation that sometimes the cheapest wood was the most expensive in terms of per ton of pulp.

Bonus Installation

The purpose of the analyses was to determine the proper materials and method to produce the desired results, then to put these into effect. The problem resolved itself into a development of standards and establishing a proper reward for meeting these standard requirements.

In a pulpmill the first consideration of a bonus suggests the basing of bonuses on final output and quality of pulp. This is unfair to nearly all the men in the plant, because only a very few men are responsible for the output, the rest having simply a routine work to do to take care of the material which passes through their machines. Instead, therefore, of the uniformity scheme, each operation was considered by itself, and a bonus fixed to satisfy the requirement of individual responsibility.

While the bonuses thus are applicable only to these individual pulpmill operations, they illustrate by their diversity the general principles for bonus payment in many manufacturing departments operating under a continuous process. Very briefly the bonuses adopted in a pulpmill will be discussed.

Bonuses in Woodroom

The preparation and cutting up of the wood is a manufacturing proposition, but nearly all the outputs are limited by the requirements of the digester. Only where the output is dependent on the men themselves, as in barking, is the remuneration based on the quantity only. Even here, in fact, the amount of bonus is affected by the quality of the work done.

The bonuses of the men who handle the sticks to the woodroom are based on uniformity of supply as recorded by a clock and in getting in the required quantity of wood on time. The bonuses of the men inspecting the logs on the carriers and throwing out the poor ones are reduced by the number of poor logs which they leave in and which the chipper men have to throw out. To balance this and also to prevent any collusion, the chipper men in turn are paid a bonus on every poor stick they throw out. Inspection of the work here as well as at other places further regulates the quality. As a matter of fact, in some of the work, such as that of the floor men and the men at the chip screens, a regular bonus is paid, provided the in-

spector, who makes his rounds at intervals, reports the work done as satisfactory.

Acid-Making Bonus

An acid-maker is paid a bonus for keeping the strength of free acid within certain limits for specified temperatures; another bonus for maintaining the required strength for SO_2 gas, as shown by an automatic recorder; and still another for firing the sulphur furnaces within two minutes of the specified time.

The men who slake the lime are paid a bonus for keeping the strength of the slaked lime to the specified Baumé tests and maintaining uniformity in the temperature of the lime water.

Standardization of Digesters

The most important operation in pulp making is the cooking of the chips. The output of the digesters governs the production of the plant. Yet even here the bonuses were not based directly on the quantity produced.

By the old-fashioned method of cooking and the method followed today by the majority of sulphite-pulp mills the manner of cooking is put up entirely to the cook. He is given certain general directions but is without sufficient apparatus to enable him to know what is going on in the digester. The first step was to provide not simply pressure gages, but recording thermometers showing by curves at all times the temperature in the digester. By a careful study of the effect of different materials and conditions a standard temperature curve was decided upon, and also a standard curve of pressure.

Reduction in Cooking Time

Figure 81 shows the results of the standardization on the time of cooking. It will be seen by reference to the two curves

that before introducing standards for the digesters, the length of cooking varied anywhere from 8½ to 12 hours. When the standard temperature and pressure curves were put into

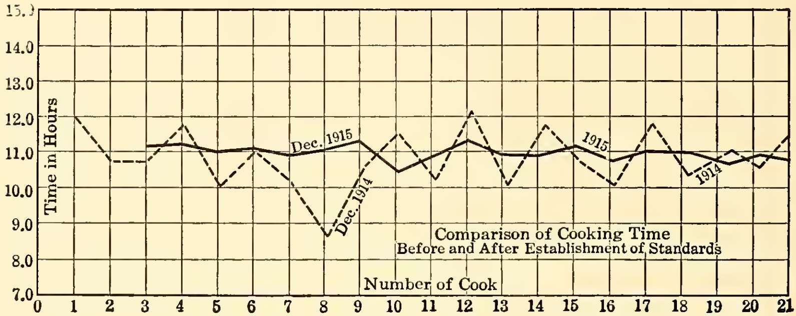

Figure 81. Cooking Times for Wood Pulp before and after Standardization

effect the cooks were asked to follow them. The uniformity in the time of cooking immediately increased and a nearly uniform time of 11 hours was obtained. This improved the quality through uniformity but it did not increase the output.

As a result of the great uniformity in the product produced, which entirely eliminated the poor cooks, it was found possible to reduce very materially the time of cooking below this later curve.

Digester Bonuses

It is sometimes considered that satisfactory increase in output and improvement in the morale of the men may be attained through the adoption of standard methods maintained by posting records of accomplishments for inspection by the workmen. In studying the question in the plant referred to here it was felt that, if, through their care, accuracy and attention, the men were able to maintain this uniform quality of pulp and thus reduce by the standard method the time of cooking they should receive not simply notice that one had

attained 85 per cent while another attained 80 per cent but they should also have a definite reward for this work well and faithfully performed. Consequently bonuses based on the accurate following of directions were established.

The temperature chart for each cooking is examined by an inspector in the office to determine how much it varies from the standard chart. Beginning 2½ hours after the cooking has started, any deviation from the standard is noted by inspection at intervals throughout the remainder of the cooking. If the curve is maintained within 3 degrees of the standard limits, the cook is paid a bonus of 3 cents per hour; if maintained within 4 degrees of the standard, he receives 2 cents an hour; within 5 degrees, 1 cent per hour; while if it runs more than this he receives no bonus at all on this division of his work. A second bonus is paid for getting the pressure up to the required point at the designated time. A third bonus is paid for blowing off the cooked pulp at the proper color. The cooking liquor grows darker as the cooking proceeds, and the exact time to blow off is governed by the color of the liquor, which can be drawn off through a cock. If the sample of liquor taken at time of blow-off is of the proper color, the cook receives a certain bonus; if the next color to it, a smaller bonus; if of the third color, a still smaller bonus. The total of the three bonuses constitutes the cook's total bonus for the day. In practice the plan works out very simply and requires very little labor because the number of cookings per day are comparatively few.

APPENDIX F

MACHINE RATES OR METHOD OF DISTRIBUTING OVERHEAD EXPENSE

The analyst must always back up his conclusions by producing figures on the reduction in the unit cost of production.

Unit cost refers to the sum total of elements entering into the cost of the product. These elements are materials, labor, and overhead expense. The unit cost is expressed in "cents per pound," "cents per thousand pieces" or some value per unit of measure, the establishment of which depends upon the nature of the industry.

The analyst must take two factors into consideration when proving what has been accomplished. A comparison must be made of the cost before and after standards have been established. The accomplishments may be proved by showing a reduction in unit labor, unit material, or unit overhead costs, or a combination of these elements.

It is usually comparatively easy to obtain the unit direct labor cost and the unit material cost. Such is not the case when the unit overhead cost is desired. Few concerns distribute the overhead expense over the cost of the product. The analyst, therefore, must have a knowledge of accounting and be able to determine the proper method of distributing the overhead expense for the factory, department, or operation involved.

There are many authoritative articles in print covering the distribution of overhead. The commonly known methods are machine rate, percentage of direct labor, man-hour and supplementary rate.

Overhead expense, frequently called burden, includes taxes, insurance, depreciation, superintendent, indirect labor, heating, lighting, salaries of planning department, fuel, and power.

Distributing overhead by percentage of direct labor method is conceded by accountants to be generally inaccurate and often leads to absurd conclusions as to the cost of the product. The rate is determined by dividing the overhead charges of a definite period by the total direct labor for the same period. The unit overhead cost is determined by multiplying the unit direct labor cost by the percentage of direct labor rates. The unit cost is then obtained by totaling the unit material cost, the unit direct labor cost, and the unit overhead cost.

The man-hour method of distributing overhead, while better in many respects than the percentage of direct labor method, is not looked upon with favor, and properly so, because it is only reasonable that different rates should apply on different kinds of work, different machines and classes of men. The man-hour rate is determined by dividing the cost of indirect labor by the total number of direct labor hours. The unit overhead cost is obtained by multiplying the number of hours of direct labor by the man-hour rate. The unit cost is obtained by adding the unit material cost, the unit direct labor cost and the unit overhead cost.

The supplementary rate methods of distributing burden is used generally in conjunction with the machine rate method. Its purpose is to have the production absorb the entire overhead for the period in which it is manufactured rather than charge the unabsorbed portion to profit and loss as would ordinarily be done. To obtain the supplementary rate—total the absorbed overhead, deduct the result from the total overhead charges for the period and divide the difference by the total overhead absorbed, the quotient is the supplementary rate. The unit cost is then obtained by adding unit material

cost, unit direct labor cost, unit overhead cost and unit supplementary overhead cost (unit overhead cost multiplied by supplementary rate).

The machine rate method of distributing overhead is the most generally accepted and is recognized as the best means of obtaining true costs, hence it is correct for all practical purposes.

It is anticipated that this illustration, taking the analysis step by step, will enable the novice to see what is required and will suggest a means to an end when a somewhat similar problem confronts him.

The first step in the process of setting machine rates for the industry under discussion was to determine the general overhead expense for a normal year. That expense was obtained from the company and while names may differ, according to the classification of accounts in different plants, the charges in any industry would be much the same in principle. The overhead expenses as enumerated herewith as well as the other values given in the example are relatively correct and not the exact values as shown by the books of the particular Company from which the figure were taken. Great care must be exercised to include the total expense on such items, for instance, which are partly bought on contract and partly manufactured at the plant such as power and light.

Total heating	$1,900.00
Total lighting	400.00
Electric lamps	125.00
Insurance, and taxes..................	4,900.00
Depreciation of buildings.............	2,500.00
Watchman	1,000.00
Elevator man and helper............	1,200.00
Repairs to buildings.................	1,200.00
Power chargeable to elevator..........	200.00
Maintenance and repairs..............	500.00
	$13,925.00

The next step was to ascertain the floor space of the factory over which the general overhead expense was to be distributed. The total floor space, 85,500 square feet, was found to be divided in the following manner:

Building No. 1	6	floors at 5,000 square feet =	30,000 square feet
Building No. 2	3	floors at 4,000 square feet =	12,000 square feet
Building No. 3	7¼	floors at 6,000 square feet =	43,500 square feet
Total			85,500 square feet

$$\frac{\$13{,}925.00 \text{ (overhead expense)}}{85{,}500 \text{ (floor space)}} = \$0.163 \text{ (rate per square foot)}$$

The company should consider carefully at this point each of the factors making up the overhead expense and determine which of these items and by what amount is likely to increase or decrease, if any. In this case the company anticipated an increase in the cost of the overhead expense and raised the figured rate of \$.163 to \$.20:

$$\$0.20 \times 85{,}500 \text{ (square feet)} = \$17{,}100 \text{ Estimated Charges}$$

By dividing the general overhead expense by the total square feet, a rate of \$.163 per square foot was reached. The management, anticipating a higher cost of overhead expense in the next period, decided to increase the rate to \$.20 per square foot. Thus they were prepared to absorb \$17,100.00 of general overhead charges.

The third step, viz., that of determining the factory overhead, gave the following results:

Space occupied by general offices, shipping, and receiving rooms = 15,000 square feet at \$0.20	\$3,000.00
Space occupied by factory = 70,500 square feet at \$0.20	14,100.00
General overhead expense	\$17,100.00

Factory Overhead

Factory expense:		
Salary of superintendent	$5,000.00	
Salaries of planning department	8,500.00	
Janitors, cleaners, etc.	1,200.00	
Sundry manufacturing expense	2,800.00	
Power	7,133.00	
Telephone service	375.00	
		$25,008.00
Proportion of general overhead expenses		14,100.00
Factory overhead		$39,108.00

$$\frac{\$39{,}108.00 \text{ (factory overhead expense)}}{70{,}500 \text{ (factory space)}} = \$0.555 \text{ rate per square foot}$$

Analysis of the floor space shows that 70,500 square feet was occupied by the factory. By taking $.20 as a basis of expense a square foot the portion of general overhead expense which had to be absorbed by the factory was equivalent to $14,100. Factory expense of $25,008 added, gave factory overhead of $39,108, or at the rate of $.555 per square foot.

The next step was to determine how much floor space was to be charged to each department. The factory occupied 70,500 square feet of which 60,200 square feet was used by six productive departments, and the balance, 10,300 square feet, was occupied by the planning and storage departments.

The productive departments had to absorb the expense which would be applied to the floor space used by the planning and storage departments if it was occupied by productive units. To each productive department had to be added its proportion of this non-productive area.

$$\frac{10{,}300 \text{ (square feet planning and storage)}}{60{,}200 \text{ (square feet productive)}} = 17.1 \text{ per cent proportion of non-productive area to be charged to productive departments.}$$

As the planning and storage departments occupied 10,300 square feet and the productive departments 60,200 square feet the proportion to be absorbed by each productive department was 17.1 per cent.

Division of Floor Space

	Square Feet	Total Square Feet Occupied	Proportion of Floor Space Used for Planning and Storage	Total Footage Charged
Signal Department:				
Building No. 3........	15,500			
Building No. 1........	3,400	18,900	3,200	22,100
Preparation Department:				
Building No. 3........	6,000			
Building No. 1........	5,800	11,800	2,000	13,800
Case-Making Department:				
Building No. 3........	5,200			
Building No. 1........	5,800	11,000	1,900	12,900
Print Department:				
Building No. 3........	6,000			
Building No. 2........	1,500	7,500	1,300	8,800
Calender Department:				
Building No. 1........	7,500			
Building No. 2........	1,000	8,500	1,500	10,000
Gold Stamping Department:				
Building No. 1........	2,500	2,500	400	2,900
Total Square Feet Absorbed		60,200	10,300	70,500

Thus it is seen that a productive department such as that of the signal department was charged not only with the space occupied by itself, 18,900 square feet, but in addition with 3,200 square feet its proportion of space required for planning and storage departments, or a total of 22,100 square feet.

To illustrate the method of establishing the rate per square

foot within a department the signal department has been selected. In the distribution of floor space this department was charged with 22,100 square feet. Multiplying this area by the factory overhead rate of $.555, the factory overhead to be absorbed by the signal department was found to be $12,265.50. To this must be added the indirect labor charged in the signal department which amounts to $3,304, giving a total department overhead expense of $15,569.50.

Signal Department

Factory overhead = 22,100 square feet at $.555 per square foot............		$12,265.50
Departmental expense:		
2 Inspectors........................	$2,000.00	
1 Moveman	704.00	
1 Machine tender..................	600.00	3,304.00
Departmental overhead		$15,569.50

The next operation was to determine the square feet occupied by machines within the signal department. To the area actually required by each machine was added the space necessary for storage of materials at the machine.

The total floor space required by machines was 15,200 square feet. The balance 6,900 square feet was used for aisles and general storage. Therefore, instead of distributing the departmental overhead to the total area of 22,100 square feet charged to the signal department it was distributed over the productive space amounting to 15,200 square feet, resulting in a rate of $1.024 per square foot in this department.

The same method was employed in setting rates on the floor space for the preparatory department with 13,800 square feet, the case-making department with 12,900 square feet, the print department with 8,800 square feet, the calender department with 10,000 square feet, and the gold department with 2,900 square feet.

Machine Symbol	Square Feet
A 1	810
B 4	300
C 10	60
D 1	270
E 1	300
E 2	200
E 3	200
E 8	1,050
E 9	1,050
E 10	1,050
E 11	1,050
E 14	1,000
F 61	800
F 71	800
F 81	850
F 82	850
G 1	4,500
H 2	60
	15,200 Square feet of space occupied

$$\frac{\$15{,}569.50 \text{ (department overhead)}}{15{,}200 \text{ (square feet)}} = \$1.024 \text{ rate per square foot in signal department}$$

After the rate per square foot was established in the signal department the next move was to set a rate for each machine. The rate per square foot multiplied by the number of square feet which the machine occupied plus the estimated depreciation gave the amount of expense to be absorbed annually by each machine. Machines E8, E9, and E10 are taken to illustrate the method of figuring.

E 8

(Overhead rate) \$1.024 × 1,050 (square feet) . .	\$1,075.20
Depreciation (10%) of cost \$2,000.00	200.00
Expense to be absorbed	\$1,275.20

E 9

(Overhead rate) \$1.024 × 1.050 (square feet) ..	\$1,075.20
Depreciation (10%) of cost \$3,300.00	330.00
Expense to be absorbed	\$1,405.20

E 10

(Overhead rate) \$1.024 × 1.050 (square feet) ..	\$1,075.20
Depreciation (10%) of cost \$2,300.00	230.00
	\$1,305.20

The last step was to establish the machine rate per hour. This was done by dividing the amount of expense to be absorbed by the per cent of time it was estimated the machine would be in operation and then by the possible working hours for the year; the result gave the estimated rate per hour.

$$\frac{\$1{,}275.20 \text{ (expense)}}{90\% \text{ (times)} \times 2{,}800 \text{ (hours)}} = \$0.506 \text{ Estimate rate per hour}$$

Machine	Description	Make	Expense to be Absorbed	Per cent of Time in Use	Estimated Rate per Hour	Established Rate per Hour
E8	Punch Press	Bliss	\$1,275.20	90	\$0.506	\$0.55
E9	Punch Press	Bliss	1,405.20	80	0.628	0.65
E10	Punch Press	Bliss	1,305.20	90	0.518	0.55

To expedite clerical work it is advisable to set the hourly machine rate in units of five cents as was done in this illustration.

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